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THE OCCURRENCE OF CARBON DIOXIDE[1]

WITH NOTES ON THE ORIGIN AND RELATIVE IMPORTANCE OF SUBTERRANEAN CARBON DIOXIDE

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OCCURRENCE

THE earliest scientific record of carbon dioxide seems to be that of Pliny,[2] who in his "Naturalis Historiae" says, "But, by Hercules! the history of the heavens themselves would not be more difficult to relate: the abundance of metals . . . the virtues of medicinal springs . . . the exhalation of deadly vapors (spiritus lethales) either emitted from caverns or from certain unhealthy districts; some of them fatal to birds alone as at Soerate, a district near the city; others to all animals, except to man, while others are so to man also:" These openings were generally called vents and, by some persons, Charon's sewers, from their exhaling a deadly vapor. The account continues by telling of a place, in Asia, where no one can enter in safety, except the "priest of the great Mother of the Gods," and of prophetic caves, where those who enter are intoxicated with the rising vapor so that they can predict future events, as at Delphi.

There is to-day no doubt about the fact that Pliny was referring to the various carbonated water springs and carbon dioxide gas vents, such as the Grotta del Cane at Pouzzoles near Naples and the many similar grottos in various parts of the world. The Grotta del Cane is particularly interesting because it has been known since very early times. It is reported to yield a gas consisting of about 70 per cent. carbon dioxide, 24 per cent. nitrogen and 6 per cent. oxygen. Inasmuch as the ratio of the nitrogen to oxygen is exactly the ratio of these gases in the air, it seems reasonable to assume that there has been an unavoidable contamination with it either at the exit or somewhere deeper under ground.

[1] Address of the president of the Southwestern Division of the American Association for the Advancement of Science, Albuquerque, N. Mex., April 27, 1938.

[2] Pliny the Elder, 2, 95 (A.D. 77).

Flammarion[3] gives the following interesting account of the dog at the Grotta del Cane in his popular book "L'Atmosphère," Paris, 1872:

> The keeper has a dog whose legs he ties together to prevent his running way; he then places him in the middle of the grotto. The animal displays evident fear, struggles to escape, and soon appears to be dying. His master then takes him out into the open air, where he gradually recovers himself. One of these dogs has been used for this purpose more than three years.

This grotto is situated on the slope of a very fertile hill, near Lake Agnano. The entrance is closed by a locked gate. It has the appearance and shape of a small cell, the walls and vault of which have been rudely cut in the rocks. It is about one yard wide, three deep and one and a half high. It is difficult to judge from its appearance whether it is the work of man or of nature. The ground in the cavern is very rich and covered with a whitish mist of carbonic acid gas and water vapor. The stratum of gas is from ten to twenty-five inches high, representing an inclined plane, the highest part of which corresponds to the deepest portion of the grotto. The grotto being about on the same level as the opening leading into it, the gas finds its way out at the door, flows like a rivulet along the hill path, and may be traced for a long distance. A candle dipped into the gas at a distance of more than six feet from the grotto is extinguished at once. Flammarion states that a dog dies in the grotto in three minutes, a cat in four, and a rabbit in seventy-five seconds. A man could not live more than ten minutes if he were to lie down. It is said that the Emperor Tiberius had two slaves chained up there, and that they perished at once. Peter of Toledo, Viceroy of Naples, is reported to have killed two men condemned to death by placing them in the grotto.

On the borders of Lake Laacher, near the Rhine, and in Aigueperse, in Auvergne, there are two sources of carbonic acid so abundant that they give rise to accidents in the open country. The gas rises out of small hollows in the ground, where the vegetation is very rich; the insects and small animals, attracted by the richness of the verdure, seek shelter there and are at once asphyxiated. Their bodies attract the birds, which also perish.

Formerly accidents caused by this gas in caves, mines and even wells gave rise to the most extravagant stories. Such localities were said to be haunted, since no trace of lesion or bruise was to be found on the unfortunate persons who were suddenly struck down.

Lake Laacher in Germany, referred to above, is the water-filled crater of an extinct volcano. The Valley of Death in Java is also an old volcanic crater from whose fissures large amounts of carbon dioxide constantly come forth. The Stygian caves in the Yellowstone National Park contain concentrations of carbon dioxide sufficiently large to make them dangerous, although it has been stated that bears hibernate in them during the winter. The boiling springs and mud pots in the Yellowstone yield gases consisting principally of water vapor and carbon dioxide. This is also true of mud pots near the Salton Sea in the Imperial Valley in Southern California.

We are probably all most familiar with subterranean carbon dioxide when it comes to the surface in the form of carbonated water, as at Nauheim, St. Moritz, Altwasser and Saltzbrunn in Europe and at Saratoga Springs, New York, the Navajo and Ute Springs at Manitou, Colorado, the Hot Springs in Virginia and the Napa Soda Springs in California.

With the advent of deep drilling for oil, carbon dioxide was discovered in various parts of the world at pressures up to about 1,000 pounds per square inch. In many cases the gas is practically one hundred per cent. carbon dioxide. Among the early discoveries of this nature was that in the Northern Tampico, Mexico, oil field. When we think of natural gas associated with oil, our first thought is that the gas consists of combustible hydrocarbons. At Tampico,[4] however, we have an area of about one hundred sixty-five square miles along the Rio Panuco, where oil is produced with a non-inflammable gas. Within this area lies the Isleta pool and the Herradura Oil Company Well No. 1. This well is reported to have come in as a salt-water gusher, yielding at the same time large quantities of carbon dioxide. As a result of the low temperatures produced by the expansion of the gas at the Corona Well No. 7 in this field, the carbon dioxide solidified as dry ice, in the heat of July, 1921, to a thickness of about an inch on the drill which was hanging in the casing.

On the eastern edge of the non-inflammable gas area lies the Quebracha field, which includes wells in Quebracha, San Isidro and Loma del Pozo. Although of no particular interest as an oil-producing field, it has attracted wide attention because of the tremendous non-combustible gas production, which runs as high as 98 per cent. carbon dioxide. The discovery well blew in from the Agua Nueva formation at a depth of about 3,000 feet in 1915, with an initial gas production rated at about 50,000,000 cubic feet per day. With favorable weather conditions the roar of the well could be heard at night for over seven miles. From 1923 to 1929 many large gas producers were discovered, at least four of which yielded one hundred fifty million cubic feet per day. Closed-in pressures were of the

[3] Flammarion, "The Atmosphere," translated by Pitman, Drallop Publishing Co., New York, 1896.

[4] Muir, "Geology of the Tampico Region, Mexico." Published by the American Association of Petroleum Geologists, 1936.

order of 1,000 pounds per square inch. The oil in the flow lines from the wells was often so cold that the moisture from the air froze on the outside for distances of almost a mile, giving an appearance similar to that of the ice on the coils in our electric refrigerators. A better notion of the magnitude of the gas flow can be obtained when we realize that if the daily production of 150,000,000 cubic feet of carbon dioxide were reduced to dry ice, we should have the enormous weight of about 9,000 tons.

According to Kemp,[5] the mineral springs at Saratoga, New York, were known as early as 1767, although it was not until 1870 that the first wells were drilled in an attempt to increase production. From 1892 to 1905 wells were drilled for the express purpose of extracting the carbon dioxide from the water. The gas was produced with water from depths as great as 600 feet from at least thirty wells. In the period from 1904 to 1908 as much as 5,000,000 pounds of carbon dioxide were produced annually. Pumping these wells resulted in the lowering of the water level at times by 150 feet. With the creation of a State Reservation at Saratoga in 1908 a legal restraint was placed on pumping, resulting in a decline of the industry.

In 1916 a gas well reported to have yielded 25,000,000 cubic feet of carbon dioxide per day was drilled in the Bueyeros field in Harding County, New Mexico, by the American Producers Corporation. The gas came from a depth of about 2,000 feet. This well, after flowing wide open for over a year, finally bridged itself and ceased flowing. The years 1925 and 1926 marked the discovery of several new carbon dioxide gas fields in New Mexico and Colorado. The California Oil Company encountered a non-combustible gas consisting chiefly of carbon dioxide on the Jaritas Dome in Colfax County, New Mexico, at a depth of 1,509 feet. Production was estimated at about 500,000 cubic feet per day. The Arkansas Fuel Company drilled a well on the Wagon Mound Anticline in Mora County, New Mexico, and after encountering gas at various levels completed the well at about 2,600 feet with a production of 26,000,000 cubic feet per day. The Estancia Company drilled a well on the Estancia Anticline in Torrance County, New Mexico, and encountered both oil and carbon dioxide, but the principal production in this area comes from some eight wells drilled since 1931 on the Wilcox Anticline northwest of Estancia. In 1926 when numerous gas wells were being discovered in New Mexico which were mostly devoid of oil, the Continental Oil Company completed a well on the McCallum Anticline in Jackson County near Walden, Colorado, which produced carbon dioxide reliably estimated at 50,000,000 cubic feet per day with some oil. In 1930 the Carbon Dioxice and Chemical Company completed a carbon dioxide well on the Farnham Anticline near Price in Carbon County, Utah. The Sierra Grande Oil Corporation drilled a well on the Sierra Grande uplift in Union County, New Mexico, in 1935 to a depth of 2,800 feet, encountering carbon dioxide of high purity at three levels, with a total volume estimated at 6,000,000 cubic feet per day. A total of nine wells have been drilled in the Bueyeros field, the deepest of which was the discovery well in 1916. Recently a well about one quarter mile from the discovery well has been completed which is reported to have a flow of 25,000,000 cubic feet per day at 700 pounds pressure. The producing sand has an estimated thickness of one hundred feet.

In 1932 the Salton Sea Chemical Products Corporation started drilling wells in the Salton Sea basin in the Imperial Valley near Niland, California, and has brought in several good producers of very pure gas. Many other areas, such as Manitou and Delta, Colorado, as well as fields in the State of Washington and in Canada might be mentioned, but the above will suffice to indicate the rather wide-spread natural occurrence of pure carbon dioxide at relatively high pressures.

Although the present paper is largely restricted to a discussion of subterranean carbon dioxide, a few observations relative to its occurrence in general will serve to fix our ideas, while at the same time showing the tremendous reserves in the air, in water and in geologic structures. Our atmosphere consists of essentially 80 per cent. nitrogen and 20 per cent. oxygen, but contains in addition small amounts of numerous other gases. Among these is carbon dioxide to the extent of about three volumes in ten thousand, or 0.03 per cent. by volume. This very low concentration nevertheless represents a tremendous total mass which has been estimated to be of the order of two million million tons. Sea water constitutes another enormous reserve, as a result of its power to dissolve the gas in large quantities. The oceans may be regarded as vast regulative reservoirs which keep the concentration of carbon dioxide in the atmosphere constant. Although the solubility is dependent on the temperature, we may assume an average value of 0.05 per cent. by volume, which leads to a total weight thirty times as great as that in the atmosphere, or 60 million million tons. No one seems to have had the courage to estimate the reserve of carbon dioxide either free or combined which exists in the lithosphere. This is not surprising when we recall that such a large proportion of underground rocks consists of carbonates. The underground reserves surpass our powers of comprehension. Clarke[6] gives us a rough estimate of the total amount of carbon in the lithosphere including all forms such

[5] Kemp, *N. Y. State Museum Bull.*, 159, 1912.

[6] F. W. Clarke, *U. S. Geol. Surv. Bull.*, 795: 55, 1920.

as coal, oil and the carbonates when he states, "The known carbon of this lithosphere, if converted into carbon dioxide, would yield nearly twenty-five times the present mass of the entire atmosphere."

Although the carbon dioxide content of the air is at present very low, it is surprisingly constant when we consider the steady large additions to it by such phenomena as the combustion of all kinds of fuels, exhalations of the animal kingdom, emanations from the earth, the decay of organic matter and many industrial processes such as fermentation and lime burning. This balance is maintained in large measure by the solution of carbon dioxide in the oceans. The cold waters of the north reduce the carbon dioxide concentration of the air to very low values because the gas is more soluble in cold than in warm water. In other words, the partial pressure of carbon dioxide over cold water is less than over warm water. As the cooler waters of the oceans reach the warmer parts of the earth, the atmosphere is enriched with carbon dioxide. As warmer weather approaches and springtime comes to cold countries, the atmosphere is also enriched with carbon dioxide. Since plants live in part on carbon dioxide we may suspect a relationship between the luxuriant vegetation of springtime and the tropics, and the release of this gas from the waters where it was stored during the colder months. This process of using carbon dioxide for plant growth is known as photosynthesis. Some of the carbon dioxide stored by the water is used up by marine calcium-carbonate-forming organisms and is eventually deposited as limestone, and large amounts are used up in the weathering of rocks. Silicates are decomposed by carbonated water yielding carbonates. Calcium and magnesium carbonates are converted to bicarbonates. These bicarbonates are water soluble and may be carried long distances by underground water currents or surface water, only to be reprecipitated as normal carbonates when the carbon dioxide content of the water is reduced either by aeration or by heat.

II. Origin

To those of us interested in the physical sciences, the origin of such vast stores of carbon dioxide in the free state at great depths is of no less interest than the uses to which the gas can be put. Many theories have been advanced which are physically and chemically possible. However, when we attempt to reconcile some of them with the experimental fact that the gas exists underground at pressures approaching one thousand pounds per square inch, we are forced to question seriously whether the processes suggested could actually yield such pressures.

Fuller[7] discusses the origin and suggests the possibility of the gas coming from the chemical decomposition of the rock by its contact with igneous intrusion. He also suggests that it may result from the decomposition of carbonates by acids of the ground water. In 1906 Delkeskamp[8] published a rather exhaustive survey of the various theories which had been advanced for the origin and made a critical physical-chemical analysis of numerous characteristic examples. He also brought together the rather widely scattered literature on the subject which had been published up to that time. Under the title "Vadose and Juvenile Carbon Dioxide," he discusses the carbon dioxide which is formed by processes near the surface of the earth and that which has a volcanic origin. The latter he assumes to be a constituent of the molten magma, released as it slowly cools off, or trapped as inclusions in the solid stone. He believes that the vadose, or superficial carbon dioxide, may come either from the atmosphere or from some organic source such as lignite, peat or marsh beds. The possibility of chemical reactions on carbonates is also mentioned.

In support of Delkeskamp's suggestion of the carbon dioxide coming from the molten lava, we should mention the experimental fact that liquid carbon dioxide is often found as inclusions in spherical cavities in crystalline quartz. Although in general the solubility of gases in liquids is greater at low than at high temperatures, we know that a change of state such as that in going from liquid to solid may force the gas out of solution.

Thus, for example, silver melted in the presence of air dissolves large quantities of oxygen from the air. If the melt is allowed to cool to its solidification temperature, the outside becomes solid, while the center is still liquid. The oxygen at the surface escapes easily, but once the surface has solidified, the oxygen from the inside has no way of escaping except by breaking through the hard layer. This it does, producing the phenomenon known to metallurgists as spitting or sprouting. Jets of gas with liquid metal come to the surface, making fantastic forms on the crust. When the surface layer becomes thick enough, the gas no longer breaks through but remains as inclusions. As a result of this, objects of silver can not be cast except in atmospheres devoid of gases which are appreciably soluble.

Lindgren and Ransome,[9] in a volume on the "Geology and Gold Deposits of the Cripple Creek District of Colorado," devote a chapter to the study of mine gases and report analyses in metal mines running as high as 14.7 per cent. carbon dioxide. Pointing out that exhalations of gases composed of carbon dioxide,

[7] M. L. Fuller, "Mineral Resources," 21: 1259, 1905.

[8] Rudolf Delkeskamp, *Z. prakt. Geol.*, 14: 33, 1906.

[9] Lindgren and Ransome, *U. S. Geol. Surv. Professional Paper*, 54: 252, 1906.

nitrogen and sometimes hydrogen sulfide always take place after volcanic eruptions, and that they frequently continue for a long time after the cessation of the igneous outbursts, the authors conclude that the mine gases of the Cripple Creek region represent the last exhalation of the extinct Cripple Creek volcano.

Guilleaume,[10] in an article on "Natural Carbon Dioxide" published in 1926, mentions the various possible organic and inorganic origins, but concludes that none of these could account for the large volumes found in the many European vents and mineral springs. After an exhaustive survey of the existing deposits in France and Germany, he calls attention to the fact that in every case there is a close relationship to basal outcrops and evidence of rather recent volcanic activity. He does not suggest thermal decomposition of carbonates, but does raise the question of the possible decomposition of carbonates dissolved in ground water coming in contact with igneous rocks, and also the combustion of carbonaceous material. Guilleaume leaves one with the impression that he favors a strictly primary origin of the gas which is in solution in the molten magma. He states that in nature, lava flows continue to give off carbon dioxide for a very long time. Lohmann[11] states that carbon dioxide from the earth's interior may be the last sign of former volcanic activity, or that it may result from thermal or acid decomposition of carbonate stones. The acids involved he believes to be silicic, from weathering processes, and sulfuric, formed from sulfides.

The occurrence of carbon dioxide in coal seams has in recent years led to a great deal of study as a result of the numerous fatal explosions caused by its sudden release. S. Bubnoff[12] published a series of articles on the geological aspects of this problem and Potoniè,[13] Ruff,[14] and Tammann and Seidel[15] studied the chemical aspects. Bubnoff suggests three possibilities for the origin: (1) the carbon dioxide is the result of normal carbonization; (2) it is the result of abnormal carbonization, that is, an enrichment as a result of the rock pressure and a chemical dynamic metamorphism; and (3) the carbon dioxide does not come from the coal, but is juvenile, coming from inside of the earth. It is the third possibility which he says must be accepted, as the various experimental facts fail to give support to the first two suggestions. The strongest arguments for a juvenile origin are the facts that these carbon dioxide explosions also occur in salt mines and that the greatest pressures of the gas are found in those coals which have been most completely carbonized. Potonié concludes that the carbon dioxide is held in the crevices in the coal by adsorption on the surface, but Ruff insists that the gas is held in solution in the coal. Both agree that the gas does not originate in the coal seams, but that it has been trapped and held there in its escape from below. In this connection it is interesting to note that carbon dioxide is more soluble in coal than is methane or marsh gas. According to data obtained by Ruff, a given mass of coal will dissolve three times as much carbon dioxide as it will methane when these gases are in contact with the coal at a pressure of ten atmospheres, or about one hundred fifty pounds per square inch.

R. F. Selden,[16] of the U. S. Bureau of Mines, in an article published in 1934 on "The Occurrence of Gases in Coals," states that whenever carbon dioxide is the principal gas evolved, the consensus of opinion seems to support the theory of an exterior source where the gas is supposed to have been generated by intrusions of igneous rock into underlying strata containing limestone or other carbonates. If intrusions are always to be found below coal beds impregnated with carbon dioxide he suggests three possibilities: (1) The limestone was decomposed thermally; (2) the carbon dioxide accompanied the igneous rocks in its ascent into the upper strata; and (3) the carbon dioxide was formed, along with new minerals, by reactions between the carbonates and some of the constituents of the intruded rock. All these hypotheses involve the retention of the gas in the coal beds and adjacent strata for long periods. Selden dismisses the possibility of thermal decomposition of limestone on the basis of the fact that at the assumed temperature of 1,000° C. of the intruded igneous rocks, the pressure of carbon dioxide resulting from the decomposition of the stone would be only four atmospheres absolute or about forty-five pounds gauge pressure. Moreover, he doubts whether the mass of intruded rock is great enough to heat an appreciable thickness of the limestone. These calculations are based on the assumption that the only carbonate present in sufficient quantities in the neighborhood of coal seams is that of calcium. The situation would be materially changed in the case of magnesium carbonate or dolomitic limestone. The fact that in some instances there is no evidence of purely thermal metamorphism of limestone adjacent to the intrusive magma is also offered as an argument against this theory.[17]

Regarding the second possibility, namely, that the

[10] Charles Guilleaume, *Rev. universelle mines*, 10: 169, 1926.

[11] W. Lohmann, "Mineralwasser,—Fabrik," 34: 823, 859, 915, 939, 1930.

[12] S. Bubnoff, *Z. Berg-, Hütten-, Salinenwesen*, 1924, 1926, 1928.

[13] R. Potonié, *Z. angew. Chem.*, 43: 767, 1930.

[14] O. Ruff, *Z. angew. Chem.*, 43, 1038, 1930.

[15] G. Tammann and K. Seidel, *Z. anorg. algem. Chem.*, 205: 209, 1932.

[16] R. F. Selden, U. S. Bur. of Mines Dept. of Investigations, 3233, 1934.

[17] W. Lindgren, *U. S. Geol. Surv. Professional Paper*, 43, 1905.

carbon dioxide accompanied the igneous rock in its ascent, Selden states that he is not aware of any definite evidence either for or against the theory, but quotes a personal communication from L. H. Adams, of the Geophysical Laboratory, that in his opinion the rock magma does not of itself contribute any important quantity of carbon dioxide to adjacent strata.

The third hypothesis, which suggests that the carbon dioxide was formed, along with new minerals, by reactions between carbonates and some of the constituents of the intruded rocks, offers many possibilities. It is the opinion of some geologists that the magma had considerable gaseous water entrapped in it at the time of the flow. If this were the case, many reactions would become possible which otherwise would have to be excluded. Thus Van Hise,[18] and Leith and Mead,[19] attribute the metamorphic changes in limestone to the action thereon of hot water solutions and the constituents of the intruded magma. Although little is known about such systems, we do know that the pressures of carbon dioxide would be greater at a given temperature than would be the case in purely thermal decomposition.

In 1932 Tammann and Seidel[20] published an article on the subject of carbon dioxide explosions in mines in which they state that the recent carbon dioxide explosions in coal and salt mines made it necessary for the scientists of Germany to investigate the physical-chemical conditions which brought them about. Regarding the origin, they admit that it is external to the coal seams and salt beds. They oppose the belief of some geologists that the origin is in the molten magma, a belief held because of the assumption that silicates act on carbonates only at the beginning of fusion. Tammann and Grevemeyer[21] showed that calcium oxide begins to act on orthoclase and leucite at 500° C., so that low temperature reactions previously unsuspected may be taking place as the result of lava flows. Tammann and Seidel, however, do not believe that carbon dioxide had its origin as a result of the action of anhydrous silica on dry carbonates, since rocks containing these substances do not occur in nature. However, they suggest that marl strata consisting of calcium and magnesium carbonate, iron and aluminum silicates, silicic acid and water which are wide-spread, may well give rise to gas pressures such as are encountered in nature.

In order to obtain evidence in support of this conclusion they pulverized three samples of dolomitic marl taken from shell limestone outcrops near Göttingen, Germany. The samples were placed in closed containers both with and without an admixture of water and heated to 100° C. After correcting for the vapor pressure of water, they found the pressure of carbon dioxide developed in twenty hours was three centimeters of mercury for the dry and five centimeters for the wet sample. Although these pressures are low, we must compare them with those over pure dry calcium carbonate, which shows no measurable pressure at 100° and at 500° C. is still of the order of one tenth of a millimeter of mercury. With this wide discrepancy at 100°, it becomes plausible that extremely high temperatures are by no means necessary to produce pressures encountered in nature. Experiments similar to those on dolomitic limestone are being carried out by Germann and Ayres in the physical chemistry laboratories in Boulder on oolitic limestone, and pressures of the same order of magnitude as those obtained by Tammann and Seidel on dolomitic limestone are being obtained.

The principal objection to a purely thermal origin for carbon dioxide is based on the assumed maximum temperature of 1,000° C. of the intrusive rocks and the value of about four atmospheres pressure which is developed by the decomposition of powdered, pure calcium carbonate, such as found in nature as calcite. In the first place, the temperature of 1,000° is only an estimate and is based on certain assumptions of pressure which might prevail in the interior of the earth. It is quite obvious that these assumptions should lead to different values from those obtained for the temperature of the same molten magma when extruded at the surface of the earth. If the gas pressures of the order of 1,000 pounds per square inch, such as are at times encountered in carbon dioxide gas wells, could be accounted for by the assumed temperatures, there would be no objection to accepting the theory of purely thermal decomposition. A very careful study of the decomposition of pure calcite has been made by Smyth and Adams,[22] which shows that at the eutectic temperature of 1,240° C., the pressure begins rising rapidly with an increase of temperature, going from about 40 atmospheres at this temperature to 70 atmospheres at 1,275° C. This is a rise of thirty atmospheres for a temperature increase of only 35° C. Moreover, seventy atmospheres is equal to 1,029 pounds per square inch, which is at least as high as any recorded in carbon dioxide gas wells.

Remembering that pressure begins increasing rapidly at the fusion point, and that these values were those for pure calcite, we turn now to the actual cases found in nature. Here we are dealing with impure

[18] C. H. Van Hise, *U. S. Geol. Surv. Monograph*, 47: 652, 1904.

[19] C. K. Leith and W. J. Mead, "Metamorphic Geology." Henry Holt and Co., 1915.

[20] G. Tammann and K. Seidel, *Z. anorg. algem. Chem.*, 205: 209, 1932.

[21] G. Tammann and C. F. Grevemeyer, *Z. anorg. algem. Chem.*, 136: 114, 1924.

[22] F. H. Smyth and L. H. Adams, *Jour. Am. Chem. Soc.*, 45, 1167, 1923.

carbonates of calcium, with mixtures of carbonates of calcium and magnesium, as well as with mixtures of all of these with the various silicates. For pure magnesium carbonate, Manchot and Lorenz[23] find that the pressure increases from a value too low to measure at 400° C. to one atmosphere at 540° C. Moreover, they calculate from their equation that the pressure would reach a value of 473 atmospheres or about 7,000 pounds at 700° C. Marc and Simek[24] obtained considerably higher values for the lower temperatures, and state that traces of water vapor when present greatly increase the speed of pressure rise. This increase in pressures as well as increase in speed of dissociation may be explained by what is known to chemists as hydrolytic dissociation. By this is meant a chemical reaction of the carbonate with water in such a way as to form magnesium hydroxide, commonly known as milk of magnesium, and carbon dioxide. This is the reverse of the reaction which normally takes place at atmospheric temperatures and pressures, in which case magnesium hydroxide takes up carbon dioxide from the air with the formation of magnesium carbonate. The behavior of a mixture of impure carbonates containing shells, all possible combinations of minerals in small amounts, and water, such as studied by Tammann and Seidel, and Germann and Ayres, is thus very easily explained, and the development of high pressures at temperatures well below 1,000° C. is to be expected. It would therefore seem reasonable to assume that the carbon dioxide found to accompany the flow of lava and to be dissolved in it may have come from the solution of this gas in the magma under high internal pressures, the carbon dioxide itself having resulted from the thermal decomposition of carbonates in contact with the heated rock. Since it is a well-known fact that the solubility of a gas in a liquid increases with pressure, large quantities would be dissolved at pressures of 1,000 pounds. As the melt came to the surface, the pressure would be reduced and the gas would come out of solution, sometimes violently, with the blowing off of volcanic ash, sometimes slowly, giving rise to the very porous lavas. This theory would seem all the more reasonable in the light of the difficulty of explaining the presence of carbon dioxide in the interior of the earth.

New Mexico, with its abundance of evidence of volcanic activity, carbon dioxide wells and limestone caves, offers a most interesting outdoor laboratory for the study of natural carbon dioxide. We may visualize the picture in the following manner. Assuming the original limestone beds to have been formed, volcanic activity visited the state, with the resulting changes in level and faulting in the various strata, subterranean intrusions of lava, lava dikes and lava flows. The igneous intrusions caused the thermal decomposition of calcareous and dolomitic rocks and the liberation of carbon dioxide and calcium and magnesium oxide. As the carbon dioxide was liberated, some dissolved in the heated rock, came to the surface, and was responsible for the formation of volcanic ash and the accompanying violent eruptions. Some moved away from the region where it was formed along the openings in the strata to higher levels, and escaped to the surface through faults. Some encountered water, in which it dissolved to form carbonic acid. These acid waters traveled underground and dissolved the carbonate rocks, forming bicarbonates which finally reached the surface in solution. As the rock was dissolved, the underground passages became larger and our underground rivers developed. Finally the supply of surface water became less and the underground streams dried up, leaving our large caves. If these caves had openings to the outside, the water which still entered slowly from the top would gradually evaporate, lose its carbon dioxide and deposit its lime in the form of stalactites on the roof and stalagmites on the floor. As a result of these processes we have vast underground passages such as the incomparable Carlsbad Caverns. Still another part of the liberated carbon dioxide was caught in the strata where it was held in underground domes, or sealed in by dikes or faults just as oil and the hydrocarbon gases are held. In New Mexico we find the gas trapped at various levels in sand strata, and the log of one well shows that from 1,995 to 2,055 feet a large flow was encountered in what was described as lime shells and sandy red shale. In some cases gas sands 100 feet thick have been found. In the drilling of these wells caves are frequently encountered, giving evidence of the removal of limestone by water charged with carbonic acid.

Following out the idea of a decomposition of the carbonate rocks by means of water and elevated temperatures, we have a picture similar to the one above, except that in this case the slightly soluble calcium or magnesium hydroxide is slowly carried away by the water, in place of being removed as bicarbonates. On reaching the air and absorbing carbon dioxide, the insoluble carbonates would again be formed and be reprecipitated as crystalline calcium or magnesium carbonates.

For many years after the discovery of our vast carbon dioxide resources, little hope was held out for their commercial exploitation. The reasons for this were: (1) the wells were so far from railroads that it was thought necessary to construct long pipe lines, a risky financial venture because of the uncertain life of the gas supply; (2) the cost of shipping liquid carbon dioxide in steel tanks to the markets was such

[23] W. Manchot and L. Lorenz, *Z. anorg. algem. Chem.*, 134: 297, 1924.

[24] R. Marc and A. Simek, *Z. anorg. Chem.*, 82: 17, 1913.

as to make the margin of profit small; (3) the dry ice industry had not developed to a point where the markets were great, and the science of its transportation was in its infancy. To-day the picture is much more encouraging, since specially insulated trucks can load up at the well with either the liquid in tanks, or the dry ice and deliver the load to points within a radius of 1,000 miles in one to three days. Specially designed refrigerator cars loaded with dry ice will lose no more than 1.25 per cent. per day, which means that even though air transportation were available at a comparable price, the advantage of speed would mean very little. Regions remote from large centers of population will find the production and transportation of dry ice made from natural carbon dioxide much more advantageous than the shipment of liquid carbon dioxide in cylinders. If the consumer wishes to have the liquid rather than solid gas, he has only to place a block of the ice in a specially designed container, screw on a lid and allow the ice to melt.

The production of both liquid and solid carbon dioxide in the large industrial centers must always be regarded as a real competitor of the natural carbon dioxide industry, since industrial gases may be used as the source of the gas. Since the production of carbon dioxide by chemical processes is dependable and may be carried out as long as we have fuel to burn, an industry based on them is apt to be much more stable than one based on the problematic life of the natural carbon dioxide supply. This means that the profits must be greater in the latter case if the investment of capital is to be warranted.

We are really just awakening to the commercial possibilities of dry ice. Its use in the packing of ice cream obviates the use of the heavy pails with the ice and salt and hence makes it possible for a truck to carry a much more valuable load. Trucks and freight cars refrigerated with dry ice not only carry a much larger payload, but the upkeep of the carrier is very materially reduced because of the absence of salt and water. Flowers packed with dry ice for shipment seem to be literally put to sleep and to remain stationary in their development until they are unpacked. The same is true in part in the storage of fruits and vegetables, although in this case the results are not always uniformly good. A great deal of research is, at the present time, in progress in the field of the preservation and rapid freezing of meats, fish and fruits, so that the future offers great things for the dry ice industry.

The rôle of carbon dioxide in plant metabolism deserves much more attention from a commercial point of view than it has received in the past. Priestley and Scheele, the discoverers of oxygen, observed oxygen exchange taking place between plants and the atmosphere, but it remained for Ingenhousz to observe in 1779 that plants give off oxygen in the light and absorb it in the dark. Later Senebier showed that the oxygen given off in the light came from the decomposed carbon dioxide which was being absorbed. In 1804 Theodore de Saussure sprouted seeds in the light and in the dark, and found that the dry weight increased in the case of the seeds in the light and decreased in the case of those in the dark, thus proving that plants need the carbon taken from the carbon dioxide as food for growth. During all this time the "humus theory" of plant growth, which assumed that the plant roots not only took up water and salts from the soil but also organic matter, was generally accepted. This theory was, however, definitely overthrown by Liebig and Sachs, who demonstrated that plants could be grown and made to bear ripe fruit in pure water and quartz sand, provided that certain mineral salts were present in the water and that the leaves were in an atmosphere containing carbon dioxide. To-day we may visualize oxygen absorption as a combustion process liberating carbon dioxide, water and energy as in the reaction

$$C_6H_{12}O_6 + 6\ O_2 = 6\ CO_2 + 6\ H_2O + \text{energy}.$$

Similarly, liberation of oxygen is the result of assimilation in which carbon dioxide and water, with the aid of the energy derived from light, are combined to form plant tissues as in the reaction

$$6\ CO_2 + 6\ H_2O = \text{energy} + C_6H_{12}O_6 + 6\ O_2.$$

Granting that the air must contain carbon dioxide if plants are to grow, the question arises if the normal concentration is sufficient to grow the maximum crops in a given length of time. We find the answer to this question, in part, in many of the older references to natural carbon dioxide gas vents and springs, where mention is made of the very abundant vegetation to be found in the environment. Numerous experiments along this line have been carried out and it has been shown that, depending on the nature of the plant studied, the concentration of carbon dioxide of the air may be increased from its normal value of three hundredths of 1 per cent. to as much as 8 per cent. without injury and with increased assimilation. Studies conducted under glass have shown increase in leaves and stalk of from 50 to 300 per cent., blooming and ripening of fruit speeded up by 10 to 25 per cent., and hence maturing one to two weeks earlier, finer flowers and, in the case of tomatoes, an increase of almost 300 per cent. ripe fruit. Experiments carried out in the open air, making use of the purified flue gases from a steel mill, have shown a 50 per cent. increase in yield in the case of beets. All this suggests that we have

been overlooking what appears to be a most promising possibility.

Our vast reserves of carbon dioxide should be put to work in increasing our crop production. In properly constructed greenhouses we could not only raise our materials in water fed with the appropriate salts, as has been done in California, but we could also feed the leaves with carbon dioxide from our gas wells. Conducting the gas over the fields is not as easy nor as economical as in enclosed places. However, since the density of the gas is greater than air, it tends to hang close to the soil where it is most needed, so that even a moderate amount let loose near the ground has a very beneficial effect. Most natural gas coming from deep wells requires no purification. The natural pressure will carry it long distances, requiring only the laying of pipe lines. Some day we shall no doubt wonder why it took so long for us to awaken to this important use of a natural resource which had been permitted to go to waste.

The Southwest is blessed with much sunshine and natural carbon dioxide; soil and water conservation projects are everywhere under way. With these assets of water, sunshine and carbon dioxide, the finest fruit and vegetable crops can be grown. When to this we add that the vast store of natural carbon dioxide may also be converted to a refrigerant, it is obvious that not only can the finest products be raised, but they may be shipped in prime condition to the nation's markets from the Atlantic to the Pacific. The history of some of the gas wells which have been permitted to blow off into the atmosphere uncontrolled leads us to believe that the life of these wells will be long. Moreover, experience has shown as a rule that the deeper we drill, the higher gas pressure we encounter. We may well ponder over these facts and ask ourselves if we do not have here the nucleus which may some day lead to an enterprise more profitable than mining has ever been. We may confidently anticipate that in the not distant future, capital looking for a good place to go to work may seize upon this project as one giving great promise of ultimate reward.

OBITUARY

WILLIAM PENN BROOKS

AT its sixty-second commencement exercises, in 1932, Massachusetts State College conferred upon a member, who had received his first degree as a member of its fifth class, the honorary degree of doctor of agriculture. Never was the degree of doctor with all the ideals and knowledge which that word should signify—never was this title more fittingly bestowed than it was upon Dr. William Penn Brooks. In the death of this man science has lost a worker who devoted forty years of constant application to studying, improving and teaching agriculture. His death occurred on March 8 at the age of 86.

Starting life on a Massachusetts farm, he took a natural interest in agriculture, an interest which he first pursued in the newly incorporated land-grant college of that state. He graduated from Massachusetts Agricultural College with its fifth class and spent two succeeding years there in graduate study of botany and chemistry. Still not firmly enough grounded for his satisfaction, Dr. Brooks traveled to Halle, Germany, where for his year's work in agriculture, botany and philosophy the Friedrichs Universität awarded him the Ph.D. degree.

From the first Dr. Brooks had shown his remarkable talent for organizing and teaching. Before his first year in college he had already taught secondary schools for two terms. In college he helped to found the national fraternity of Phi Sigma Kappa. Yet it is worthy of notice that this young scholar was called directly from Halle halfway around the globe to the Island of Sapporo, Japan, in order that he might aid in the establishment upon a sound, scientific basis of the Imperial College of Agriculture. For eleven years he fostered the growth and welfare of that institution, acting as president for some time and earning for himself the honorary degree Nogaka Hakushi, and later the decoration of the Fourth Order of the Rising Sun.

After this productive eleven-year sojourn in the Orient, Dr. Brooks returned to his Alma Mater, where he taught agriculture as professor and lecturer from 1889 to 1918. Twice he was president *ad interim* of that college, and from 1906 to 1918 he was director of the Massachusetts Agricultural Experiment Station. During the whole period of his thirty years of active work at Amherst, he was associated with this station and was a leader both in experiment and organization. The results of his research and scholarly efforts he published in numerous reports to the bulletins of the experiment station, the state board of agriculture and to the Massachusetts Horticultural Society. He was also the author of the annual reports of the experiment station for twelve years. He published a three-volume text, entitled "Agriculture," which treated of soils, manure and crops and animal husbandry. All these works, together with his several writings for the Imperial College of Agriculture, in Japan, were constant sources of contemporary reference and had a profound influence upon the trend of agricultural instruction in all the land-grant colleges of the United States.

It was only under the compulsion of a Massachusetts law that the venerable Dr. Brooks retired in 1921 at the age of 70. Keen and progressive to the end (his death was the result of a fall), Dr. Brooks flew across

the continent to California in his eighty-fourth year, alone, to visit his son. Besides that son, Dr. Sumner P. Brooks, of the University of California, he is survived by his second wife (Grace L. Holden); his daughter, Mrs. George Drew; three grandchildren; and three great-grandchildren.

Dr. William Penn Brooks was not a "nationally known and advertised" figure, none of his achievements sky-rocketed him to fame; but he was a patient and methodical researcher, a thorough and discerning organizer and a sincere and significant teacher. Science honors his memory.

F.S.

RECENT DEATHS AND MEMORIALS

DR. HERBERT W. MUMFORD, dean of the College of Agriculture of the University of Illinois, died on May 31 as the result of an injury suffered in an automobile accident on May 14. He was sixty-seven years old.

DR. A. E. BOYCOTT, professor emeritus of pathology at the University of London, died on May 12 at the age of sixty-one years.

MRS. MARGIE A. SMITH, widow of the late Edgar Fahs Smith, formerly professor of chemistry and provost of the University of Pennsylvania, has added $5,500 to the endowment of the Edgar Fahs Smith Memorial Library of Chemistry at the university following earlier contributions of more than $50,000 for the same purpose. The income will be used for the purchase of books, journals and prints. Since 1931 the library has been housed in specially constructed rooms in the Harrison Laboratory of Chemistry and it now embraces nearly 10,000 items.

"MOSQUITO DAY" was observed at the London School of Hygiene and Tropical Medicine by a gathering representative of scientific and medical interests and professional, industrial and colonial life who met to commemorate the work of Sir Patrick Manson and Sir Ronald Ross.

SCIENTIFIC EVENTS

THE CHEMISTRY ADVISORY COUNCIL

THE Chemistry Advisory Council, 300 Madison Avenue, New York, N. Y., as successor to the Committee on Unemployment and Relief for Chemists and Chemical Engineers (also known as the Chemists' Unemployment Committee), according to a report in *Industrial and Engineering Chemistry,* is endeavoring to study the question of unemployment of members of the chemical profession. Unemployed chemists are encouraged to register with the council and, in turn, the council will render assistance in several directions, be it advice or more tangible relief where the urgency of the case demands the latter course.

The council plans, as soon as conditions permit and the finances are available, to establish a bureau of employment to bring together employers and applicants. Meantime it maintains a registration of unemployed chemists, with rather complete case history.

In the first four months of 1938, the council has registered 97 unemployed chemists or chemical engineers, all of whom qualify under one of the three groups: registrants having a B.S. degree with two or more years' industrial experience; registrants having an M.A. degree with more than one year's industrial experience; registrants having a Ph.D. degree. The ages of these registrants fall into the following groups: 45 and above, 12; 35 to 44, 30; below 35, 47; unknown, 8. The classification according to education: Ph.D., 15; M.A. or M.S., 25; B.S., 57. The classification according to industrial experience: less than 5 years, 31; 6 to 10 years, 19; 11 to 20 years, 30; over 20 years, 17.

Four non-graduates having more than five years of industrial experience sufficient to qualify them as chemists or chemical engineers have registered. These men have all attended one or more institutions of higher education but do not possess chemical degrees.

Ninety-five persons have registered possessing: B.S. degree or its equivalent, but less than 2 years' industrial experience; master's degree with less than one year's experience; foreign degrees where the educational status can not be exactly classified.

The total registration for the four months amounts to 196, and has increased much more rapidly during the second quarter than during the first quarter.

THE SECOND EASTERN PACIFIC ZACA EXPEDITION OF THE NEW YORK ZOOLOGICAL SOCIETY

FOR a second time Templeton Crocker placed his yacht *Zaca* at the disposal of the Tropical Research Department of the New York Zoological Society. The resulting expedition, which was the twenty-sixth undertaken by the department under the direction of Dr. William Beebe, left San Diego on November 6, 1937, and remained five months in the field.

Mr. Crocker accompanied the expedition together with Maurice Willows. The physician was Dr. Eric Liljencrantz, of Stanford University. The scientific personnel, as on the first *Zaca* expedition, consisted of Dr. Beebe, *director;* John Tee-Van, *general associate;* Miss Jocelyn Crane, *technical associate,* and George Swanson, *artist;* Toshio Asaeda, *photographer and preparateur.*

Linking up with the route of the first *Zaca* trip, the natural faunal area beginning at Cedros Island on the west coast of Lower California was followed south to Panama—a zone of life which, except for the latter bay, is very slightly known. The chief object was to study as thoroughly as possible the fish, crabs and mollusks from tide-pools down to five hundred fathoms, with more emphasis placed on ecological relationships, colors and habits than on collecting. Constantly in mind, as a major problem, was the accumulation of field data of use in evaluating the relationship of corresponding Atlantic and Pacific forms.

On the way south the expedition stopped at forty bays, large and small, and from one to ten days were spent in each. Among these were Banderas, Manzanillo, Tangola Tangola, Fonseca, Port Parker, Murcielago, Culebra, Piedra Blanca, Nicoya, Dulce, Golfito, Chiriqui and Bahia Honda. Many of the smaller bays have a geographical isolation which gives them peculiar interest, almost insular in character. The extreme difficulty of reaching the majority by land lends especial value to the opportunity of studying them for considerable lengths of time while living close in-shore on the *Zaca*. Calm weather accompanied all the activities except when passing through the limited zones disturbed by the "Tehuantepeckers" and "Papagaios."

The gradual change southward in the land flora and fauna, from absolute desert conditions in Lower California to typical, tropical rain forest such as that at Golfito, was as dramatic as it was instructive, and the shift from clear sea-water in the north to more silted bays fed by fresh-water streams provided a host of unexpected problems.

Especial attention was paid to the life-histories of the Brachyura, and elaborate notes were made on upwards of two hundred species. Over a hundred thousand individual fish were examined on the decks of the *Zaca*, representing a generous percentage of the total species in this faunal area. Twelve hundred photographs and several hundred colored paintings were obtained.

Space permits the mention of only two or three of many interesting or new forms. Young Pacific sailfish, *Istiophorus greyi*, as small as 42 and 84 millimeters, standard length, were obtained for the first time. Both came to night lights and a thousand miles apart. Intensive collecting in tide-pools and observation of their inhabitants by day and night provided interesting material. As many as seventy-one species of fish were taken in a single pool. *Dixonina* was rediscovered in the Pacific, and both adults and larvae taken nine hundred miles south of the former single record at Acapulco. New genera and species of abyssal ceratiads with attached parasitic males were trawled from a half mile depth. All the commercial tuna fishermen met with were most generous in donating desirable specimens of unusual size or species.

After refuelling at Balboa, the *Zaca* was headed south for the island of Gorgona, off the coast of Colombia, where an intensely busy and profitable week was spent. The results, in the case of both vertebrates and invertebrates, showed this little known place to be a meeting point of three distinct faunas.

The collections are now all at the laboratory of the Tropical Research Department in the New York Zoological Park where Dr. Beebe and his associates will work upon them for the rest of the year.

CORRESPONDENT

GRANTS IN AID FROM THE PERMANENT SCIENCE FUND OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES

THE following grants in aid from the Permanent Science Fund of the American Academy of Arts and Sciences were announced at the meeting of the committee on April 13.

Professor Ernst C. Abbe, University of Minnesota, $500, toward expenses of a phytogeographical expedition to the coast of Hudson Bay, contingent upon an additional $2000 being secured elsewhere.

Professor C. E. Allen and Professor D. C. Cooper, University of Wisconsin, $600, for technical assistance in further histological and cytological studies of root nodules on legumes.

Orlan M. Arnold, the Rensselaer Polytechnic Institute, $300, for materials in a study of design and construction of apparatus for precise measurement of electrical characteristics of proteins, enzymes, hormones and other organic substances.

Dr. Charles T. Berry, the Johns Hopkins University, $247, toward the expenses of collecting fossil Ophiurans in a micro-paleontological problem of stratigraphy.

Professor William C. Boyd, the School of Medicine of Boston University, $600, for assistance in a study of blood groups in Egyptian mummified bone and muscle.

Frank K. Edmonson, Indiana University, $500, toward the cost of a photometer for astronomical purposes, contingent upon the remaining cost being secured elsewhere.

Professor Llewellyn T. Evans, the State University of Montana, $180, for the purchase of animals and materials to continue a study of the effect of certain hormones upon reptiles.

Professor Frank T. Gucker, Jr., Northwestern University, $650, for assistance in a study of heat capacities and heats of dilution of solutions of amino acids.

Miss Margaret Harwood, director of the Maria Mitchell Observatory, $500, for assistance in computations on photographs of the Scutum star cloud.

Professor Hans O. Haterius, College of Medicine of the Ohio State University, $200, for the purchase of

animals for a study of anterior-hypophyseal activity and effects.

Professor Rachel E. Hoffstadt, the University of Washington, $250, in further support of a study of the virus of infectious myxomatosis of rabbits and of related viruses.

Professor Norton A. Kent, of Boston University, $500, for assistance in further measurements of the wavelengths of molecular spectra of hydrogen isotopes.

Professor Donald H. Menzel, the Harvard Observatory, $950, toward the cost of fabrication of an electric coronagraph of original design, for the study of the solar corona outside of total eclipse.

Dr. John Rock, the Free Hospital for Women, Brookline, Mass., and Dr. Austin H. Brues, Harvard Medical School, $1,000, for continuation of a study of the electrical disturbances associated with human ovulation, and attempt to recover, fertilize and culture human ova.

Felix Saunders, the University of Chicago, $200, for materials to continue studies of the relation between configuration of carbohydrates and their utilization by bacteria.

Professor Joseph H. Simons, the Pennsylvania State College, $500, for technical assistance in continuing a study of the physical and chemical properties of the fluorocarbons.

Dr. Irwin W. Sizer and Dr. Bernard S. Gould, the Massachusetts Institute of Technology, $300, toward the cost of a Barcroft-Warburg apparatus in a further study of bacterial dehydrogenase.

Professor Carl G. Vinson, the University of Missouri, $500, for special apparatus for use in further investigations of active crystalline virus fractions.

Income from the Permanent Science Fund of the American Academy of Arts and Sciences, according to agreement and declaration of trust, shall be applied to such scientific research as shall be selected, in "such sciences as mathematics, physics, chemistry, astronomy, geology and geography, zoology, botany, anthropology, sociology and economy, history and philology, engineering, medicine and surgery, agriculture, manufacturing and commerce, education and any other science of any nature or description whether or not now known or now recognized as scientific; and may be applied to or through public or private associations, societies, or institutions, whether incorporated or not, or through one or more individuals."

Applications for grants under this indenture are considered by a committee of the academy on stated dates only. The next such meeting will be to consider applications received in proper order on blank forms furnished by the committee on October 1. Correspondence, including requests for application forms, should be addressed to the chairman of the committee on the Permanent Science Fund, Professor John W. M. Bunker, Massachusetts Institute of Technology, Cambridge, Mass.

COLLOID CHEMISTRY AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE fifteenth Colloid Symposium of the Division of Colloid Chemistry of the American Chemical Society is being held at the Massachusetts Institute of Technology on June 9, 10 and 11. An attendance of five hundred is expected. Twenty-five reports from leading college and industrial laboratories are to be presented.

Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, delivered the opening address on Thursday morning. The first scientific paper was presented by Dr. Wolfgang Ostwald, of the University of Leipzig. His subject was "Colloid Coagulation and Electrolyte Activity."

Among those who are taking part in the symposium are: Dr. Wanda K. Farr, of the Boyce Thompson Institute for Plant Research; Professor William D. Harkins, of the University of Chicago; Professor James W. McBain, of Stanford University; Professor Arthur W. Thomas, of Columbia University; Dr. Alfred J. Stamm, senior chemist of the U. S. Forest Products Laboratory, Madison, Wis.; Dr. Maurice L. Huggins, of the Eastman Kodak Company, Rochester, N. Y.; Professor Wesley G. France, of the Ohio State University; Dr. Harry B. Weiser, of the Rice Institute, Houston, Texas, chairman of the Colloid Symposium Committee; and Professor Warren K. Lewis and Dr. Ernst A. Hauser, of the Massachusetts Institute of Technology. Dr. Hauser is secretary of the Colloid Division.

Following the symposium, the third special summer program in theoretical and applied colloid chemistry and physics will be opened on June 13 at the Massachusetts Institute of Technology under the direction of Dr. E. A. Hauser, associate professor of chemical engineering. This is offered to men actively engaged in industry or in research. It will last for five weeks and will consist of lectures, round table discussions and laboratory investigations. Guest speakers from various industries, as well as experts in the field of colloid chemistry and physics, will address the group during the course.

SCIENTIFIC NOTES AND NEWS

DR. VANNEVAR BUSH, vice-president and dean of engineering of the Massachusetts Institute of Technology, was elected on June 2 president of the Carnegie Institution of Washington, the appointment to take effect on January 1, 1939. He succeeds Dr. John C. Merriam, who was elected president in 1921 and will become president emeritus.

A DINNER in honor of Dr. Ross G. Harrison, since

1927 Sterling professor of biology at Yale University, who will retire from active teaching at the end of the academic year, was given on May 29 at the Obsorn Zoological Laboratory, of which he is director. Dr. Harrison has served as a member of the faculty for thirty-one years.

AT the annual commencement of Columbia University on June 1 the honorary doctorate of science was conferred on Alfred Chester Beatty, London, mining engineer; on Gano Dunn, electrical engineer, president of J. G. White and Company, Incorporated, New York City, and on Thomas Parran, Jr., surgeon general of the U. S. Public Health Service.

THE degree of doctor of laws was conferred on June 4 by the University of Maryland on Dr. Gilbert H. Grosvenor, president of the National Geographic Society.

FRANKLIN AND MARSHALL COLLEGE at its commencement on June 1 conferred the degree of doctor of science on Dr. Robert Franklin Mehl, director of the Bureau of Metallurgical Research at the Carnegie Institute of Technology, Pittsburgh.

AT the seventy-seventh annual commencement of the Louisiana State University the doctorate of science was conferred on Dr. Lee A. Strong, chief of the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture.

THE honorary degree of doctor of engineering was conferred at the commencement exercises on May 27 of the Colorado School of Mines on Director William R. Chedsey, of the Missouri School of Mines and Metallurgy "for distinguished service in engineering education."

THE University of Oxford will confer the honorary doctorate of science on Dr. Geoffrey Ingram Taylor, Yarrow research professor of the Royal Society.

AT the seventy-fifth annual commencement at the Kansas State College on May 30 honorary degrees were awarded as follows: *Doctor of science*—Miss Lita Bane, head of the department of home economics, University of Illinois; Ula May Dow, of the class of 1905, head of the department of foods, Simmons College; David Fairchild, of the class of 1888, formerly in charge of Foreign Seed and Plant Introduction, U. S. Department of Agriculture; Merritt F. Miller, dean-elect of the College of Agriculture, University of Missouri; and William A. Hagan, of the class of 1915, dean of the New York State Veterinary College; *Doctor of engineering*—William L. Enfield, of the class of 1909, manager of the Edison Laboratories at Nela Park; *Doctor of laws*—William M. Jardine, formerly Secretary of Agriculture, and now president of the University of Wichita.

THE Isaac Adler Prize of $2,000 for 1938 has been awarded by Harvard University to Dr. Wendell M. Stanley, of the Rockefeller Institute for Medical Research, Princeton, N. J., for his work on the isolation of crystalline forms of the filterable viruses. The Adler Prize was founded in 1934 by a bequest of $20,000 made by Mrs. Frida Adler, of New York City, in memory of her husband.

PROFESSOR E. T. BELL, of the California Institute of Technology, has been awarded the gold medal of the Commonwealth Club of California for his book entitled "Men of Mathematics." The medal is awarded for "the best scholarship and research work published during 1937."

ZETA BETA TAU, national college fraternity, has awarded the New Orleans Trophy for 1938 to David Dietz, science editor of the Scripps-Howard Newspapers, in recognition of his newspaper writings during 1937. The trophy has been awarded annually since 1931 to "the member of the fraternity whose record for the past year is most outstanding."

THE Lister Medal for 1939, which is awarded in recognition of distinguished contributions to surgical science, has been granted to Professor René Leriche, professor of clinical surgery in the University of Strasbourg. He will deliver the Lister Memorial Lecture in 1939 at the Royal College of Surgeons of England. This is the sixth occasion of the award, which is made by a committee representative of the Royal Society, the Royal College of Surgeons of England, the Royal College of Surgeons in Ireland, the University of Edinburgh and the University of Glasgow.

DR. EUGENE F. DUBOIS, professor of medicine at the Cornell University Medical College, New York City and physician-in-chief at the New York Hospital, was elected president of the Association of American Physicians at the recent Atlantic City meeting.

AT the annual meeting of the Mining Association of Great Britain, held in London recently, Sir Evan Williams was reelected president for the twentieth successive year.

PROFESSOR HENRY R. FRANCIS, of the New York State College of Forestry at Syracuse University, has resigned after serving for twenty-four years.

DR. EARL C. MCCRACKEN, assistant professor of physics at the Iowa State College, has been appointed head of the department of physics at Teachers College, Columbia University. He has been a member of the Iowa State College staff for fifteen years.

DR. WILLIAM MASON HALE, who has been on leave of absence from the department of bacteriology of

Yale University, has been appointed professor and head of the department of bacteriology of the College of Medicine of the State University of Iowa.

DR. LELAND WILBUR PARR, bacteriology, and Dr. Benjamin Douglass Van Evera, chemistry, have been promoted to full professorships in the George Washington University.

DR. RALPH P. AGNEW, who has since 1925 been associated with the department of mathematics of Cornell University, has been promoted to a professorship in mathematics, not in physics, as stated in a recent issue of SCIENCE.

PROFESSOR H. H. READ has been appointed from January 1, 1939, to the university chair of geology tenable at the Imperial College of Science and Technology, University of London. Since 1931 he has been George Herdman professor of geology in the University of Liverpool.

THE Peiping Union Medical College has announced the appointment of Dr. I. Snapper to its chair of medicine. Dr. Snapper, who has been professor of medicine in the University of Amsterdam and director of the clinic for internal medicine in the Wilhelmina Hospital since 1919, expects to arrive in Peiping for the opening of the college session in September.

DR. ALEŠ HRDLIČKA, of the Smithsonian Institution, left Washington on May 26 for his seventh expedition to Alaska and the Aleutian Islands.

DR. HARRY PLOTZ, of the Pasteur Institute, Paris, arrived in New York City on May 30 and attended the twenty-fifth reunion of his class at the College of Physicians and Surgeons of Columbia University. He will spend the summer here, working in laboratories and visiting friends. Dr. Louis Martin, director of the Pasteur Institute, who has been visiting the United States, sailed for France on June 1.

DR. SIGMUND FREUD, founder of psychoanalysis, who is now eighty-two years of age, has left Vienna and has gone to London. According to press reports, Dr. Freud was allowed to take his manuscripts with him, but his other property has been confiscated.

DR. F. C. MANN, director of the Institute of Medical Research of the Mayo Foundation, has been invited by the Royal College of Surgeons, London, to deliver a special lecture in July of this year on "The Aetiology of Peptic Ulceration."

DR. A. C. CHIBNALL, of the University of London, will give the Silliman Lectures at Yale University, beginning on October 12. His subject will be "Metabolism of Protein in the Green Plant." Dr. Richard Goldschmidt, director of zoology at the University of California, has been appointed Silliman lecturer for the year 1939–40. The series, the title of which is not yet announced, will begin on December 4.

DR. ARTHUR H. COMPTON, professor of physics at the University of Chicago, will deliver the commencement address at the forty-fifth annual graduation exercises of the Drexel Institute of Technology, Philadelphia, on June 20. Dr. Compton will take as his subject "Some Implications of Science."

DR. DAVID RIESMAN, professor of the history of medicine of the University of Pennsylvania, delivered the Shattuck lecture before the Massachusetts Medical Society on May 31. The subject of the lecture was "American Contributions to Nosography."

THE first session of the council at the Ottawa meeting of the American Association for the Advancement of Science will be held at 2 P. M. on Monday, June 27, in the Tudor Room of the Chateau Laurier. Subsequent sessions of the council will be held in the same room at 9 A. M. on days to be determined at the first session. The business to be placed before the council is normally first presented to the executive committee for its consideration and recommendation. If there are any matters of general policy or wide interest that members desire to present to the council, they should be transmitted, if possible, before the meeting, to the permanent secretary, Dr. F. R. Moulton, Smithsonian Institution Building, Washington, D. C.

THE International Astronomical Union will meet at Stockholm from August 3 to 10. The preliminary announcements state that owing to the large number of tourists visiting Stockholm in August it will be advisable for members to reserve their lodging through the intermediary of the local committee. The Swedish railways will give members a reduction of 25 per cent. on railway tickets in Sweden. The Swedish Lloyd Company gives members a reduction of £1 on first-class return tickets from London to Göteborg.

THE International Conference on New Theories in Physics opened in Warsaw on May 30 under the auspices of the International Institute of Intellectual Cooperation of the League of Nations. Delegates from ten countries were in attendance. Those from the United States included Professor Samuel A. Goudsmit, of the University of Michigan; Professor John von Neumann, of Princeton University, and Professor Eugene P. Wigner, of the University of Wisconsin.

A GROUP of college teachers of geology from Beloit, Coe, Cornell, Knox, Drury and Augustana Colleges met recently at Augustana College to discuss problems of common interest. After a day of meeting, the group organized under the name of the "Association of College Geology Teachers." The following officers were elected: *President*, Dr. F. M. Fryxell, Augustana

College; *Vice-president,* Dr. Miner, Cornell College; *Secretary-treasurer,* Professor Edward L. Clark, Drury College. The next meeting will be held in the autumn under the auspices of Cornell College, with Dr. Miner as host. Dr. W. H. Norton, of Cornell College, professor emeritus, will be a special guest of the meeting. It is hoped that all colleges offering major study in geology will find it possible to send representatives to this meeting.

FROM Library of Congress originals, under the editorial direction of Colonel Lawrence Martin, chief of the division of maps in that institution, the United States Constitution Sesquicentennial Commission is publishing a series of maps depicting the thirteen original States from New Hampshire to Georgia at the time of the formation of the Constitution. There will be at least 18 maps in the series, including Maine, Kentucky and Tennessee (formerly portions of Massachusetts, Virginia and North Carolina, respectively) as well as two maps of the United States of that period. These maps are printed in brown and red, or in brown and green, or in black and green, on sheets twenty inches by twenty-six. It is understood that these colored maps are sold for ten cents a sheet, or eighteen maps for $1.50. The maps show the roads, the mineral resources, the mills, the cities, villages, counties and other evidences of administrative control that existed in the United States 150 years ago. The commission is also preparing a series of simplified, black-and-white maps which appear in newspapers. For information regarding the distribution of these maps, those interested should write to The United States Constitution Sesquicentennial Commission, Washington, D. C., Sol Bloom, Director General.

MORE than 58,000 plants, collected in all parts of the world, were received during the academic year 1936–1937 at the Gray Herbarium of Harvard University. Of these, more than 32,000 mounts were added to the organized collection, bringing the number of specimens to about 950,000. The collection of North and South American flora represents more than a hundred years of continuous, carefully directed growth. Field parties went out from the herbarium during the year to make collections in Virginia, Cuba, Canada and Alaska. Collections were received in the course of the year from the following foreign countries: Cuba, Colombia, Costa Rica, Brazil, the Aleutian Islands, Jamaica, Mexico, Quebec and Ontario. In the same period, 265 series, amounting to 26,732 duplicates, were sent in exchange to 90 herbaria in 22 different countries, and 68 loans of about 6,000 technically important specimens were sent to specialists in this country, Argentina, Great Britain, Germany, Holland and Sweden.

THE London *Times* states that the Grand Council of the Federation of British Industries has decided to support the proposals of the Advisory Council of the South Kensington Science Museum for the substantial development of the museum, and a letter has been sent on behalf of the federation to the president of the Board of Education supporting the Advisory Council's recommendations. In 1910 a committee appointed by the government recommended the erection of three blocks for the museum, but it was not until 1928 that the block which at present houses the Science Museum was completed. The Advisory Committee now considers that the 1910 proposals are not adequate and recommends that the whole of the site bounded by the eastern wall of the existing museum, and by Exhibition Road, Imperial Institute Road and Queen's Gate, be finally allocated to the Science Museum.

THE *Bulletin* of the American Society for Testing Materials reports that a Federal laboratory for the testing of materials is being established in Caracas, by the Minister of Public Works, Venezuela. It will provide for Venezuela a laboratory functioning much as does the National Bureau of Standards or the British National Physical Laboratory. This laboratory is now virtually complete and most of the equipment, of which the larger part was supplied by firms in the United States, is installed. A new building, single story, of modernistic design has been built to house this equipment. Offices for personnel are provided and plans are being made for the acquisition of data on strengths and other properties of materials found in Venezuela.

THE London *Times* reports that the King Edward Hospital Fund for London has purchased a special car for the conveyance of radium in connection with the Central Radium Pool which it has established for the benefit of London hospitals. Although never more than a gram of radium will be carried, the car has a specially designed safe, surrounded by 2 cwt. of lead, to protect the driver. Every day portions of the radium, which is lodged at the Middlesex Hospital, will be carried from one hospital to another as required.

A COMMITTEE of study on the determination of molecular and atomic weights of gases through physico-chemical methods assembled on December 17 and 18 in Neuchâtel. It was organized by the International Institute of Intellectual Cooperation assisted by the International Council of Scientific Unions and by the International Unions of Physics and Chemistry. Two reports were the basis of the discussion, the first on the method of limiting-pressures, established by Professors Whytlaw-Gray and Cawood, the second on the method of limiting-densities, established by Professor E. Moles. Professor Jaquerod presided over the assembly, which was attended by Professors Whyt-

law-Gray (Leeds), Moled (Madrid), Lepape (Paris), Klemenc (Vienna), Timmermans (Brussels), Keesom (Leyden) and Cawood (Leeds). The committee called attention to the international features of the laboratories of Leeds (Whytlaw-Gray) and of Madrid (Moles), owing to the results they obtained, as well as to their equipment and specialization of their staff. The reports will be published by the International Institute of Intellectual Cooperation. At the assemblies of the committee to be held during the present year, the following questions will be discussed: "New Vitamines"; "Nomenclature of Genetics"; "New Theories of Modern Physics"; "Coordination of Scientific Terminologies" and "The Double Electric Couch."

DISCUSSION

AN INVITATION TO TEACHERS OF SCIENCE

A BRIEF account of the first meeting of the committee appointed by the American Association for the Advancement of Science to consider the improvement of science in general education has already appeared in SCIENCE, May 20. This report was prepared by Professor Caldwell, as chairman of the older committee on The Place of Science in Education, which has sponsored this newer committee, and which assisted in its organization at Columbus on April 30 and May 1.

The new committee will require the active cooperation of many teachers of science at the college and university level if it succeeds in unearthing the information with the discovery of which it has been charged. It is hoped that such cooperation will be stimulated by a brief statement of the present objectives.

It is generally agreed that the training of professional scientists has reached a high degree of effectiveness in the United States. But there is increasing evidence, from many quarters, that the present contribution of science to the general education of the bulk of our citizens is not what it should be. To analyze this problem, to secure adequate information about what is already being done to improve matters and to develop a program of investigation which will lead to more wide-spread improvement, is the task of this committee. More immediately, the committee has at its disposal sufficient funds to enable it to do preliminary work, in the hope that by the middle of 1939 a program of sufficient value to warrant further support can be developed and presented.

To accomplish this preliminary work effectively the widest cooperation from the scientific professions is necessary, and it is the purpose of this note to invite such assistance. Waiving any less direct considerations and placing the matter on the plane of enlightened self-interest, this cooperation ought to have a very practical outcome. For example, scientific work was the first to feel the pressure of retrenchment a few years ago, just when it should have been extended. With a public more adequately aware of the value of science there would be less danger of the repetition of such folly. There are other considerations of a more serious kind, but this one should suffice.

We have decided as our first step to invite the cooperation of individuals and societies as well as of teaching departments and divisions in our work. In carrying forward our preliminary work we should like to have submitted to us a detailed and precise statement of the aims that individuals, departments or institutions are seeking to achieve in general science courses in so far as these go beyond preparation for technical and vocational training.

It should perhaps be mentioned that techniques have been developed to measure with considerable accuracy the degree to which any explicit aims are achieved by teaching. It is hoped that eventually the committee may be able to place facilities for such evaluation at the disposal of those who are interested. But obviously the first task is that of acting as a center for comparing and finding the common factors in the various objectives in science teaching for general education, taking due cognizance of the wide variation in local conditions and searching, for whatever common aspects there may be back of all this inevitable variety.

In addition, information as to studies already under way towards the coordination of science instruction, syllabi, special instructional methods including visual education, testing and teacher preparation, will be welcomed.

Such material may be sent directly to the chairman of the committee or to any of its members.

Tentatively the committee has phrased its immediate task as follows: "In connection with a preliminary survey, to request information concerning experimental modifications of general courses in the sciences at college level. A general course is defined as a course open to students without college prerequisites, which utilizes material from a considerable portion of the science in question; which should make a contribution to the general education of the student; and which is not primarily a preparation for further work in the subject."

L. W. TAYLOR, *Chairman*
OBERLIN COLLEGE

R. W. TYLER, *Vice-chairman*
OHIO STATE UNIVERSITY

A. C. KINSEY, *Secretary*
INDIANA UNIVERSITY

VIRUSES—LIVING OR NON-LIVING?

THE question of the nature of the viruses is producing a rapidly expanding volume of literature. Rawlins and Takahashi[1] have recently given citations to much of the pertinent literature so that their citations will not be repeated here. They contend that the "non-living" nature of viruses still remains to be proved in spite of the many assertions in the literature that the viruses are of the nature of the protein molecules. It is the purpose of this note to call attention to certain other arguments in favor of a living organism.

In the first place the use of the term molecule as derived from ultracentrifugal, diffusion or other physicochemical measurements does not necessarily signify characteristic homogeneity. Such "molecular weights" refer to any particle which behaves from the kinetic standpoint as a unit, each unit acquiring from thermal vibrations an average of $\frac{1}{2}\ kT$ ergs of energy for each of three translational degrees of freedom, neglecting quantum restrictions. Such a definition is vastly different from the chemist's definition of a molecule, *i.e.*, the smallest particle of a substance which can exist as an independent entity.

The "molecular weights" which have been assigned to viruses and the bacteriophage range all the way from 20,000,000 to 300,000,000. Assuming that the specific gravity of the particle of the molecular weight of 300,000,000 approximates the specific gravity of egg albumin and that the particle is spherical, the bacteriophage with the molecular weight of 300,000,000 would have a diameter of approximately 0.05 μ. The particle would thus approach the lower limit of microscopic visibility.

For the purposes of our discussion a naked cell, such as an amoeba, may be considered as consisting of two radically distinct parts, the cytoplasm and a nucleus. Studies in microdissection have demonstrated that the greater part of the cytoplasm can be cut away and, if the nucleus is uninjured, the cytoplasm will be regenerated and the organism will continue to live. We must accordingly attribute two functions to the nucleus of the amoeba, (1) the ability to regenerate amoeba cytoplasm and thus to provide the appropriate environment surrounding the nucleus, and (2) the ability to reproduce its own kind through the process of cell division. In view of the many complex chemical substances characteristic of the cytoplasm, it is perhaps not amiss to believe that the synthetic requirements of the nucleus necessitate a much larger mass of material than would be necessitated if the sole function of the nucleus was reproduction.

We know of various degrees of parasitism. Parasites exist which are relatively non-specific and which can utilize a great variety of hosts as food sources. We are also familiar with special kinds of parasitism where the host range is greatly restricted. Still more specialized forms are the obligate parasites which are restricted to a single host and in many instances to a particular variety within a particular species. It is perhaps legitimate to suggest that the obligate parasite may have lost some of its synthetic functions and has to depend upon a particular host, manufacturing some special chemical necessary for the environment of the parasite's cell nuclei.

If the above picture were projected a little further we might arrive at a living organism, the cell nuclei of which had lost all or nearly all the synthetic functions necessary for the production of cytoplasm and had retained only those nuclear functions necessary for building nuclear material (chromatin) and for cell division (reproduction). This hypothetical organism would be so perfectly adjusted to the host that it would adopt the host's protoplasm as its own cytoplasm and would be wholly dependent upon the host for its nutrition, retaining only the reproductive function which would tend to perpetuate the "naked nuclei." It is conceivable that a naked nucleus deriving its energy from a "borrowed cytoplasm" would lose the phenomenon of respiration which we have hitherto believed characterizes all living organisms and that accordingly when these naked nuclei are isolated in quantity, it will be found that they do not exhibit most of the characteristics which we have considered to be inseparable from "life."

It is well known that the viruses are highly specific, and the recent virus preparations of Stanley and others have demonstrated that "nucleoproteins" (chromatin is composed largely of nucleoproteins) can be isolated from infected tissue. Perhaps these are the hypothetical naked nuclei postulated above.

That this is a possibility is evidenced by the observation of Beams[2] that fertilized eggs of *Ascaris suum* could be centrifuged at approximately 150,000 times gravity for 4½ days and still develop into normal organisms and that the development proceeded at about the same rate as the controls. Furthermore certain of these eggs underwent cleavage while still rotating in a field of 100,000 times gravity. If no microscope had ever been developed which would render visible an *Ascaris* egg, we would have a situation somewhat analogous to that of the virus "proteins" excepting much more extreme. Such particles would be found to be spherical in shape, to sediment at a uniform velocity, and to give the usual protein tests. Because they were not visible in the microscope, we would say

[1] T. E. Rawlins and William N. Takahashi, SCIENCE, 87: 255–256, 1938.

[2] H. W. Beams and R. L. King, SCIENCE, 84: 138, 1936.

that they appeared to be homogeneous particles of a "molecular weight" of 1,000,000,000 or more.

The crystalline-appearing structures isolated by Stanley are another argument advanced in favor of the non-living nature of the viruses. The biologist, however, need only be reminded of the fact that many colonies of unicellular organisms assume special shapes or forms characteristic of the group of individual organisms making up the colony. Furthermore many bacteria tend to arrange themselves in clusters or in long chains, probably at least in part because of the positive and negative polarity which each cell possesses. We know nothing as to the electrical phenomena which would be associated with naked living nuclei, and it is not beyond the realm of possibility that such electrical phenomena would be manifested by specific orientations and specific space groupings of such naked nuclei.

The hypothesis of naked nuclei would account for the "autocatalytic" reproduction of the virus "proteins." It should be pointed out that Woods,[3] in 1899, concluded that the viruses were enzymes and that they were non-living. Unfortunately for Woods the term "autocatalytic" had not yet been coined so that he could not call the virus an autocatalytic enzyme and thus account for its self-propagation. Had he used that terminology, his description would have been essentially that of the present school who insist on the protein nature of viruses. It should be pointed out, however, that all of the classical autocatalytic reactions which have been studied in the chemical laboratory refer to a tearing down process (a chain reaction) whereby energy is released, and the writer does not know of a single instance of a building-up autocatalytic reaction whereby energy is stored. Therefore, if the viruses are autocatalytic proteins, they represent a type of chemical reaction entirely distinct from systems which have been previously studied.

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POSSIBLE LANDSLIP SCARS ON THE BOUQUET RIVER AT WILLSBORO, N. Y.

THE Bouquet River enters Lake Champlain two miles east of the town of Willsboro, N. Y., after having crossed the belt of lower Paleozoic sediments that lie between the lake and the Adirondack Mountains. In places, the river rests upon bedrock as at the bridge at Bouquet, where it exposes the Potsdam sandstone, and at Willsboro, where ledges of the Beekmantown limestone are visible and serve as the foundation of a dam. Throughout a large part of its course, however, the river is not resting on bedrock, but has cut its channel through unconsolidated Pleistocene sands and is in places flowing on an underlying bed of glacial lake clay.

In the middle of June, 1937, an interesting landslip took place on the east bank of the river about one half mile north of the Essex-Willsboro town line at the point where the river turns westward. For a distance of about five hundred feet, the clay bed of the stream was forced upward, temporarily ponding the flow of water until a new channel was cut in the meadow lands to the west. At this point the east bank rises some sixty feet above the bed of the stream and is made up of Pleistocene sands and clays, while the land to the west is relatively low. At some distance back from the river, on the east bank, a vertical scarp over thirty feet high was produced by the disturbance. Between this zone of slippage and the river, the land was badly broken and dropped vertically in blocks. Trees were uprooted, and one tree six inches in diameter was split up the middle of the trunk for several feet as the ground on one side dropped to a lower level.

Considerable local interest was aroused by this slide, and some of the local newspapers carried articles about the event. Dr. D. H. Newland, New York state geologist, visited the region a few days after the slump and has prepared a paper which will discuss the geology of the landslip.[1]

It is the purpose of this paper to call attention to a topographic feature present along the Bouquet River which might be interpreted in two different ways, either as a river terrace or as the evidence of a former slide.

The writer, who was fortunate enough to be in the region, visited the scene on June 24 and came to the conclusion that the load of Pleistocene sediments on the east bank had caused a displacement along a clay layer at the level of the stream bed and had produced the bulging of the river bottom. Slides of this type have been described from other parts of the Hudson-Champlain valley by Newland,[2] who lists five types of slides and slips which may occur in unconsolidated sediments. His fifth type, "Subsidence of surface from unbalanced pressure upon confined liquid substratum, leading to a reciprocal upward movement at a distance" is the type here represented, and the examples cited by him seem to agree in all major points.

In approaching the area of the recent slide, one crossed a definite well-developed bench about fifteen or twenty feet below the level of the glacial sand plain. The natural interpretation would be that it was a normal river terrace. However, after having seen the results of the slide the question of origin becomes more doubtful, for a bench of this type could well have been produced by a similar slide at some much earlier date.

[3] A. F. Woods, *Centr. Bakt. Parasitenk.*, 2: 745–754, 1899.

[1] D. H. Newland, Personal communication, 1938.
[2] D. H. Newland, *N. Y. State Museum Bull.*, 187, 1916.

The top surface of the bench would, under these conditions, represent the surface of the sand plain lowered to its present position by the subsurface flowage of the underlying clay bed. Any evidence of the clay bulge in the river channel could long since have been ruined by the river.

The fact that slides of this type have occurred in the past in the valley of the Bouquet River was substantiated by a talk with Dr. Stafford, a physician at Essex, who said that a similar one had occurred near Whallonsburg about seventy-five or eighty years ago.

It is therefore suggested that people working in regions of unconsolidated sediments where the same type of subsurface conditions exist, give careful consideration to this alternative before they described occasional benches as river terraces.

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HATCHING OF THE EGGS OF THE "FAIRY SHRIMP"

BECAUSE of their occurrence always in temporary pools which are dry during the summer months the belief has arisen that the eggs of the "fairy shrimp" *Eubranchipus vernalis* will hatch only after a more or less prolonged period of desiccation and possibly only after they have been frozen. To my knowledge there is for any of the American species of this genus no record of their hatching having been observed under laboratory conditions. Although others have recorded the hatching of the eggs of related European forms without their having been dried,[1] it is of some interest to record the hatching of *Eubranchipus* eggs under laboratory conditions which have precluded the possibility of drying or freezing, even if the instance was entirely accidental and only one specimen was observed which attained a size which made it clearly recognizable as this form.

In March, 1937, mature *Eubranchipus,* the females bearing eggs, were placed in an aquarium used for the "conditioning" of tap water for use in other cultures. About three fourths of the water had been withdrawn from this aquarium at intervals of approximately two weeks for use in other cultures. These animals died within ten days, releasing eggs before or at the time of death. In late January of this year a single specimen fully a centimeter in length was discovered in this aquarium. It was observed daily over a period of about three weeks until it died, no apparent growth having taken place in that interval. It is not surprising that more individuals were not found, if more were hatched, as no care is taken in siphoning off water to see that small swimming forms are not removed. It is rather surprising that this individual remained and found sufficient food for growth to the size observed. The development of this form is known to be through a nauplius stage,[2] and to attain the size and degree of development observed hatching must have taken place a number of weeks previously, near to the time believed to occur for individuals in nature in this latitude.

Factors which induce the hatching of Phyllopod "resting" eggs are obscure. It is known for some Cladocera[3] that changing the culture medium sometimes induces resting eggs to hatch without the expected period of dormancy found in nature. It may be that the periodic changing of water was of importance in this instance. There is no evidence in this case of any factor which might induce hatching prior to the normal resting period of some eight months that occurs in nature. It seems clear, however, that drying or freezing are not indispensable factors, as the possibility of either is precluded in this instance.

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SOCIETIES AND MEETINGS

THE FIFTIETH ANNIVERSARY OF THE AMERICAN ASSOCIATION OF ANATOMISTS
1888–1938

ON the 17th of September, 1888, in response to the invitation of Dr. Alex. H. P. Leuf, of Brooklyn, who had lately moved to Philadelphia, fourteen gentlemen attending the Congress of American Physicians and Surgeons in Washington, met at Georgetown University and organized the American Association of Anatomists. "Eminent professors declared that this new society was not needed; while others were convinced that it would be a difficult matter to fill the necessary offices." Fifty years have passed; and on April 14 to 16, the association, now the largest of the national anatomical societies, with a membership exceeding 600, celebrated its jubilee, at the University of Pittsburgh.

At the opening session, the large auditorium of the Mellon Institute was filled to capacity as six former presidents reported their current investigations, indicating something of the range of interests now comprised under "anatomy." First, Dr. Harrison, experimenting on Amblystoma, analyzed four factors concerned in the normal development of the ear—epidermis, mesoderm, hind-brain and position of the rudiment—assigning to each its relative importance.

[1] Mathias, *Bull. Soc. Zool. France,* 54: 342–344, 1929.

[2] Dawydoff, "Embryologie des Invertebres," 1928.

[3] Wood and Banta, *Intern. Rev. d. gesamten Hydrobiologie und Hydrographie,* 35: 229–242, 1937.

Dr. Bensley then described an extract of protoplasm which produces, on dilution, acidification or dialysis, a fibrous mass microscopically like the fibers of subcutaneous connective tissue: this substance he names plasmosin. Dr. Jackson, by weighing the various organs of underfed rats, has determined which organs suffer most; and has found that on refeeding, the variable rates of gain are such that ultimately the several organs resume nearly normal proportions. Dr. Sabin reported on the cellular reaction of healthy guinea pigs to tuberculo-protein—a reaction greatly enhanced by the addition of tuberculo-phosphatide, which acts as a potent sensitizing agent. Dr. Streeter dealt with classical embryology, discussing the origin of the entoderm in macaques. The successful sectioning of an implanting chimpanzee embryo, younger than any available human specimen, led several anatomists to visit his laboratory en route to and from the meeting. The morning session concluded with Dr. Stockard's account of the developmental independence of the upper and lower jaws as shown in hybrid races of dogs, the undershot and overshot products being "morphologic misfits and physiologic failures," with counterparts in human development. Later in the meeting Dr. Warren Lewis, absent in Philadelphia to receive, with Mrs. Lewis, the Gerhard medal for "eminent work in pathology," presented his motion picture of the distinctive behavior of lymphocytes and monocytes in tissue cultures. Dr. Herbert M. Evans also reported later, on experimental deciduomata stimulated by lactogenic and adrenocorticotropic hormones. These former presidents were allowed longer than the routine ten minutes.

Five simultaneous sessions for the reading of papers were held on Thursday afternoon, and again on Friday morning. There were round-table discussions in endocrinology, Dr. Allen, chairman; in gross anatomy—"some aspects of the pelvis and vertebral column," Dr. Meyer, chairman; in neurology, Dr. Hinsey; and in haematology, Dr. Downey. Two hundred and eight papers and 68 demonstrations—nine of them motion pictures—produced an overcrowded three-day program, and a committee was authorized to deal with this increasingly difficult problem.

On Thursday evening, preceding a lively and protracted "smoker," the Anatomists attended the annual public lecture of the American Association of Physical Anthropologists. Professor Weidenreich, of the Peiping Union Medical College, spoke on *Sinanthropus pekinensis*. His superb lantern slides of the skulls of gorilla, sinanthropus and man, seen from every angle, might well impress the public that the Peking man was the long-sought intermediary, and a final demonstration of human evolution.

The annniversary dinner of the Anatomists, at the Hotel Schenley, on Friday, April 15, was a gala occasion, with 243 in attendance. Chancellor John G. Bowman, of the University of Pittsburgh, welcomed the visitors and commented on the university's Cathedral of Learning, the tallest schoolhouse in the world, towering 535 feet, and daringly designed to express through Gothic architecture the spirit or purpose of the university. In a few of its hundreds of rooms the sessions of the Anatomists were commodiously accommodated.

From the White House, Washington, the Anatomists received the following letter, from the President:

To the American Association of Anatomists I wish to convey my warm congratulations on the completion of fifty years of activity as a scientific body.

Perhaps yours, more than any other scientific discipline, combines the rigors of an exact science with the latitude of a biological science. Anatomy, including comparative anatomy, forms the framework on which numerous other sciences are based. Though many of your number have been active in fields which a few decades ago may not have been thought of, by some, as explicitly anatomical, you have maintained cohesion, and in your ranks are numbered leaders in anatomical knowledge and discovery.

We continually and vitally need your help in maintaining and increasing the body of anatomical knowledge available, and the American public will be the gainer if your organization will keep intact this history of service.

(Signed) FRANKLIN D. ROOSEVELT

And the association replied:

Mr. President:

Stirred by your message of encouragement and congratulation, the American Association of Anatomists celebrating its fiftieth anniversary in Pittsburgh's Cathedral of Learning, will renew its efforts to meet its biological problems.

Multum adhuc restat operis, multumque restabit.

In cordial response to your interest in our welfare,

For the Association,

GEORGE W. CORNER, *Secretary*

Cordial greetings were received from Secretary von Eggeling of the Anatomische Gesellschaft, with a photograph of its Königsberg session of 1937. For that entire meeting, to the honor of American Anatomists, the Gesellschaft had appointed Dr. Harrison president. It was recalled that Kölliker was the first president of the German Anatomists, with Gegenbaur, His and Waldeyer, vice-presidents, all of whom had been made honorary members of the American Association. Nothing should stand in the way of perpetuating this traditional friendship, ardently cherished by both organizations. In an official communication sent with "herzlichste Glückwünsche," Secretary von Eggeling continues:

Die American Association of Anatomists kann heute mit Stolz und Befriedigung auf die gewaltigen Erfolge ihrer fünfzigjährigen wissenschaftlichen Arbeit zurückblicken

Dabei haben sich mannigfache, fruchtbringende und freundschaftliche Beziehungen zu der Anatomischen Gesellschaft herausgebildet, die wir sehr hochschätzen. Es ist unser aufrichtiger Wunsch, dass sie auch in Zukunft erhalten bleiben und sich weiter noch immer enger gestalten mögen.

The Polish Society of Anatomy and Zoology, through its president, Dr. Hoyer, and its secretary, Dr. Loth, sent, with several volumes of its Proceedings, "best wishes for the fiftieth anniversary: may the coming period be one of full prosperity to your Association." Report was made of the members we have in common with the Association des Anatomistes, the Società Italiana, and other national societies of anatomists, with whose activities the American Anatomists would keep in closest touch. But next of kin is the Anatomical Society of Great Britain and Ireland, "1 year, 4 months and 11 days, our senior," whose "cordial and fraternal greetings" were very happily expressed at Pittsburgh by Dr. John Beattie, their delegate.

The after-dinner speakers then reviewed the history of the American Association, which the president, Dr. Frederic T. Lewis, had divided into three periods. The first, extending from the foundation in 1888, through the 14th session, in 1900, at Johns Hopkins University, ended with the establishment of the *American Journal of Anatomy*. It was a coming of age. The presidents had been successively Leidy, Allen, Dwight, Baker, Wilder and Huntington, and the predominant interest was gross human anatomy. It happens that none of the fourteen who attended the first session survives. Professor McMurrich, present at the second session, recalled our first president, Dr. Leidy, "as one of our greatest native naturalists—anatomist, zoologist and paleontologist—a man of the most charming simplicity." Finely characterized in a bronze commemorative medal, coined for this anniversary, Leidy is portrayed by our colleague, Dr. R. Tait McKenzie, as initiating "fifty years of achievement."

The association's second period begins in 1901 with Dr. Huntington's second term as president, and extends to the armistice year, 1918, in which no meeting was held. During that time the Association's chief interest was in embryology. Its policies were molded by a triumvirate of leading spirits—Huntington, Minot, and Mall. Thus Professor McClure described these friends of his, in reminiscence of this expanding period. They served in turn as presidents, being followed by McMurrich, Piersol, Harrison, Huber and Donaldson. On the screen, portraits were shown of all former presidents now deceased, and their work was briefly presented. With great regret the Association paid its tribute to Dr. Donaldson, its most recent loss, recalling the gracious and scholarly manner in which so often he presented to the Society the substantial results of his careful researches.

The third period, with the rise of endocrinology, experimental embryology and histology, and a sustained and growing interest in neurology, is that of the present day. Dr. Weed dealt with it lightly, picturing the Association from the Secretary's viewpoint. He described "the frantic days of arranging the program and editing the abstracts"—when indeed the Secretary must serve as "Concertmeister, naming the people he would place among the first violins—the petulant cornetists, the blatant trumpeters.—Who among us plays the piccolo?"

It was observed, by the president, that the semicentennial of the American Anatomists coincides with the centennial of Schwann's *Untersuchungen*. In 1838, with a title page usually discarded, Theodor Schwann published all that was essential for his cell theory, ending Heft 1 in the midst of a sentence—"In diesem Cytoblastem, nicht." Huxley judged rightly—"Whatever cavillers may say, it is certain that histology before 1838 and histology since then are two different sciences, in scope, in purpose, and in dignity." Hence the American Association paid its tribute of admiration to Schwann and his associates—leaders in anatomy's advance.

Dr. Evans, in forecasting our future, noted that 1838 was exactly four centuries from the *Tabulae Sex* of Vesalius, the work of that "lithe youngster whose family crest was the weasel." Yet there remains as "our predominant task, the determination of the role which structural arrangements play in the understanding of life processes—this is to-day's position of anatomic inquiry, and it also connotes the direction of our movement."

Many another feature of the celebration might be mentioned—the participation of women in the association: two members in the first period, distinguished, but still inarticulate; 4 per cent. of the membership in 1903, and active participants; 9 per cent. at the present time. Letters were received from Dr. Coghill, president from 1932 to 1934, who found it inadvisable to attend, and from Dr. Gage, recalling the third session. The cordial good wishes of the association were conveyed to them by telegram. Finally, at the dinner, on the retirement of Dr. Corner from the secretaryship after eight years of service, a small glass Graeco-Roman pitcher of the 1st or 2nd century B.C. was presented to him, with the comment: "The labors of the Secretary of this Association require sacrifice. They take valuable time and curtail research. Often the results are considered transient and much of the labor lost. But sometimes there is surprising permanency in presumably fragile products. Hardly did the craftsman who made this pitcher before Galen was puzzling over the lymphatics suspect its fate. We present it to

Secretary Corner to suggest our confidence that this work for us shall endure. The Association is not unmindful of his eight years of devoted and successful service."

The concluding session on Saturday afternoon was held jointly with the Physical Anthropologists. There were three valuable papers of some length from each association. Especially noteworthy was Dr. Hrdlička's exhibition of a series of human tibiae having a large and long subcondylar process hitherto unreported, and still unexplained. Dr. Hrdlička remarked that all the major human bones have macroscopic features as yet undescribed. The final paper, by Dr. Edwards, showed how the distribution of the five pigments or color factors of the human skin may be recorded in life, by spectro-photometric measurements.

At the business meeting, 43 new members were received. Officers for 1939 and 1940 were elected as follows: *President,* Stephen W. Ranson; *First Vice-president,* T. Wingate Todd; *Second Vice-president,* Albert Kuntz; for 1939–1943, *Secretary-Treasurer,* Eliot R. Clark; *Members of the Executive Committee,* George W. Corner, Olof Larsell. A cordial invitation in behalf of the Faculties of the three Medical Schools in Boston—Boston University, Harvard and Tufts—was received from Dean Burwell; and accordingly the Anatomists will meet next year at the Harvard Medical School, in Boston, from April 6 to 8, 1939.

FREDERIC T. LEWIS
GEORGE W. CORNER

EASTERN SECTION OF THE SEISMOLOGICAL SOCIETY OF AMERICA

FOLLOWING the meeting of the American Geophysical Union in Washington, D. C., the Eastern Section of the Seismological Society of America held its thirteenth annual meeting at the Massachusetts Institute of Technology, Cambridge, Massachusetts, and Weston College, Weston, Massachusetts, on May 2 and 3, 1938.

The vice-president, Dr. Dean Vannevar Bush, in the name of Dr. K. T. Compton, welcomed the group to the Massachusetts Institute of Technology and expressed the hope that the excellent work being done in the field of seismology would very soon obtain a more wide-spread recognition on the part of the general public.

After the usual business routine, the reports of the various permanent and standing committees and the appointment of new committees, the first twelve scientific papers were presented. Following a luncheon in the Walker Memorial Building, as guests of the department of geology, a trip of inspection was made. This included an examination of the differential analyzer and a visit to the electrical engineering department shops, where a much larger and improved type analyzer is being constructed. The seismologists next examined Professor A. C. Ruge's shaking-table equipment and L. B. Slichter's new type portable seismographs. Moving over to Harvard, the Bridgman high pressure apparatus, the Birch equipment for the determination of velocities and a modern portable seismic outfit were successively inspected.

The sessions of May 3 were held at Weston, where after a brief address of welcome by the Reverend R. A. Hewitt, S.J., president of Weston College, the second group of ten papers was read and the officers for the ensuing year were elected as follows: *Chairman:* H. E. McComb, of the U. S. Coast and Geodetic Survey; *Vice-Chairman:* A. C. Ruge, of the Department of Civil Engineering, Massachusetts Institute of Technology; *Secretary:* A. J. Westland, S.J., Department of Geophysics, Saint Louis University; *Treasurer:* A. C. Chick, of Providence, R. I.; *Fifth Member of Executive Committee:* E. C. Jacobs, of the University of Vermont.

Weston College was host at the luncheon which terminated the activities of the morning. In the afternoon a visit was made to the elaborate new seismic vault at the college. Four papers were next read concerning the Benioff seismograph, and a round-table discussion followed on the Benioff operation, with Dr. E. A. Hodgson, of the Dominion Observatory, Canada, as chairman. The meeting was brought to a close with a visit to the Harvard Station at Oak Ridge to inspect the seismograph equipment there, and the 61-inch reflecting telescope of the Astronomical Observatory.

A. J. WESTLAND,
Secretary

SPECIAL ARTICLES

VITAMIN A AND ROD-CONE DARK ADAPTATION IN CIRRHOSIS OF THE LIVER[1]

DISTURBANCES in vision such as nightblindness have long been associated with malnutrition,[2] and in recent years this has been shown to be due specifically to variations in the vitamin A content of the body.[3] Lately, this relationship has received a rational understanding in terms of the association of vitamin A with the chemical structure of visual purple, the light-sensitive substance of the rods.[4]

It has generally been assumed that disturbances in

[1] Reported at the Symposium on Biophysics held at the University of Pennsylvania on November 6, 1937.

[2] H. de Gouvea, *Arch. f. Ophthalm.*, 29 (1): 163, 1883.

[3] L. S. Fridericia and E. Holm, *Am. Jour. Physiol.*, 73: 63, 1925; K. Tansley, *Jour. Physiol.*, 71: 442, 1931.

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vitamin A metabolism involve rod vision alone, and it is on this basis that the dark adaptation of the rods has been proposed[5] as a diagnostic sign for vitamin A deficiency. However, because of the many similarities which rod vision and cone vision show,[6] in such functions as intensity discrimination, visual acuity, flicker and even dark adaptation, it seemed likely that disturbances might also be found in cone function.

There have been indications that this is correct. Intensity discrimination is influenced by the vitamin A content of the body;[7] and apparently this influence exists even at high intensities, where cone function predominates. If it could be demonstrated that vitamin A controls cone function, we should gain an insight into the chemistry of cone vision which would be particularly valuable because of the low concentration of sensitive substance in the cones,[8] and the consequent difficulty of direct chemical investigation of it. It is the purpose of this note to report that vitamin A does indeed affect both cone and rod functions. The measurements which demonstrate this are concerned with the dark adaptation of persons having cirrhosis of the liver, and with the effect upon it of vitamin A therapy.

The reason for choosing this disease is that night-blindness and keratomalacia have been reported in liver disease[9]; more particularly, our own observations on persons with alcoholic cirrhosis of the liver showed that some of them possess evidences of nutritional deficiency such as lesions of the skin and cornea which suggest the specific lack of vitamin A. Since the liver is the chief depot for storage of vitamin A,[10] it is probable that disease of the liver would disturb the metabolism and storage of this vitamin.

Our measurements were made using a newly designed adaptometer[11] which determines the course of dark adaptation under controlled conditions of pre-adaptation, retinal location, color, and the like, specifically chosen so as to separate cone from rod dark adaptation and to furnish enough of the course of both functions for accurate comparison. The white pre-adapting brightness is 1600 millilamberts and is viewed by the subject for 4 minutes. The test light passes through a violet filter (Corning 511) which transmits the spectrum only below 460 mμ, and is a flash of 0.2 second duration. The retinal region tested is a circular area whose diameter subtends 4.5° visual angle, and is located 8.5° nasally in the right eye.

Of the 14 persons with alcoholic liver cirrhosis tested, 13 showed plain evidence of disturbances in dark adaptation. None of them was jaundiced.[12] Two of these patients were fed large daily doses of vitamin A.[13] After 19 daily doses of 40,000 international units, the dark adaptation of one patient became normal. The other patient, whose liver cirrhosis was more extensive, responded more slowly and exhibited normal dark adaptation only after a ten-fold increase in the vitamin dosage. The measurements made on the latter patient will be considered in detail.

Fig. 1 shows graphically three sets of these measurements made at different times during vitamin A therapy. Curve C is after 127 days of therapy and corresponds to that usually obtained with normal people. It records the way in which the light intensity threshold changes in the dark, and shows the usual rapid primary cone adaptation followed by the slow

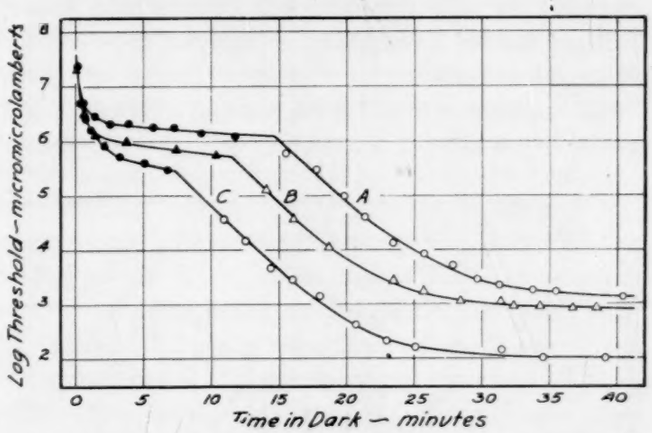

FIG. 1. The course of dark adaptation of a person with alcoholic cirrhosis of the liver determined at different times during vitamin A therapy. The points are single measurements and record the visual threshold to violet light during a stay in the dark following 4 minutes light adaptation to 1600 millilamberts. Those measurements which even at the threshold appear blue or violet to the subject are represented as solid symbols; they all fall on the primary cone portion of the curve. Those measurements which are reported as colorless at the threshold are shown by unfilled symbols, and represent the secondary rod portion of the adaptation. Curve A was obtained when the subject was on an ordinary diet. Curves B and C were obtained after 105 and 127 days respectively of vitamin A therapy. Note that both the cone and rod thresholds change and that the cone-rod transition point changes in different stages of the treatment.

[5] P. C. Jeans, E. Blanchard, and Z. Zentmire, *Jour. Am. Med. Assn.*, 108: 451, 1937.

[6] S. Hecht, *Physiol. Rev.*, 17: 239, 1937.

[7] C. Edmund and S. Clemmesen, "On Deficiency of A Vitamin and Visual Dysaptation," Copenhagen, 1936, 92 pp.

[8] S. Hecht and R. E. Williams, *Jour. Gen. Physiol.*, 5: 1, 1922; G. Wald, *Nature*, 140: 545, 1937; A. M. Chase, SCIENCE, 87: 238, 1938.

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[10] T. Moore, *Biochem. Jour.*, 25: 275, 1931.

[11] S. Hecht and S. Shlaer, *Jour. Opt. Soc. Am.*, 28: 1938 (in press).

[12] M. D. Altschule, *Arch. of Path.*, 20: 845, 1935.

[13] We used oleum percomorphum, carotene, and a vitamin A concentrate. The vitamin A concentrate (free of vitamin D) was supplied to us by the Vitex Laboratories, Harrison, N. J., through the kindness of Professor T. F. Zucker, of Columbia University.

secondary rod adaptation. The transition between the two is sharp and occurs after about 7 minutes in the dark. The data marked A were obtained when the subject had been on an ordinary diet for three weeks; those marked B were obtained after 105 days of vitamin A therapy.

There are two points of significance in these data. First, the time of appearance of the cone-rod transition is much longer for curves A and B than for normal. During treatment this transition point moved from its initial value of 15 minutes until at the end of the treatment it occurred at 7 minutes much as with the normal eye. Second, the A and B data show thresholds much above the normal, and this applies both to the cone section and to the rod section of the curves. During treatment the cone threshold was lowered by a factor of 5, and the rod threshold by a factor of 150—a ratio of 1 to 30.

The precise way in which the rod and cone thresholds varied in this subject is shown in Fig. 2. The points

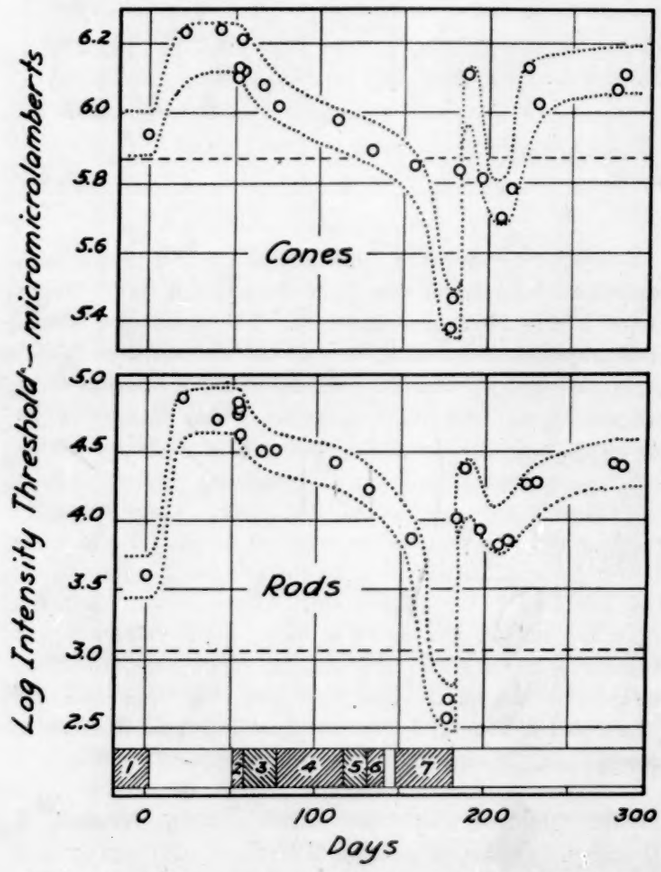

FIG. 2. Relation of cone and rod thresholds during dark adaptation to the sequence of vitamin A therapy. Daily vitamin A dosages in international units are as follows: (1) 40,000 units in oleum percomorphum, (2) 75,000 units in a D-free concentrate, (3) 60,000 units of carotene, (4) 60,000 units in oleum percomorphum, (5) 250,000 units in a vitamin D-free concentrate, (6) and (7) 500,000 units of the same concentrate. The clear spaces represent no vitamin A administration.

record the positions of the cone threshold after 6 minutes in the dark, and the positions of the rod threshold after 20 minutes, and both positions are plotted against days of therapy. Since the rod threshold variation is about 30 times that of the cones, the thresholds of the latter have been plotted on a proportionately larger scale. The median threshold of 15 normal individuals is represented by a dashed line. Through the measured points there has been drawn a band 0.3 log unit wide for the rods, and 0.15 log unit wide for the cones. The width of the band represents the extent of the extreme day-to-day variation that is found with normal people, and also with untrained patients of this type. This does not represent variations in the apparatus or in procedure, but in function and physiological condition. The therapeutic treatment is indicated at the bottom of the figure. A clear space means a normal diet with no added vitamin A, while a filled-in space represents some form of added vitamin A as explained in the figure legend.

When the subject was first tested, that is at 0 days in Fig. 2, he had been receiving 40,000 units of vitamin A daily for 58 days. At that time his cone threshold was only slightly higher than median normal and his rod threshold 0.55 log units above median normal. The rod data thus indicated a moderate degree of vitamin A deficiency. The treatment was discontinued, and 21 days later he was tested again. The thresholds of both functions had risen considerably. They fluctuated about this high level until the resumption of treatment, which took place on the 53rd day and continued with increasing daily dosage as indicated in the figure. Improvement was steady but slow until the dosage was increased to 250,000 and then to 500,000 units, when the threshold dropped precipitously to a point well below median normal. On discontinuance of treatment the thresholds rose rapidly, decreased again for about 20 days, then again rose to a high level.

The most striking aspect of these changes is the fidelity with which the cone thresholds vary with the rod thresholds. Since the rod thresholds apparently are changing in response to alterations in vitamin A concentration, the concomitant cone threshold variations indicate a similar dependence upon the presence of the vitamin. It is likely, therefore, that vitamin A has a chemical relation to visual violet resembling the one it has to visual purple.

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THE CHOLINERGIC ACTION OF OESTRIN

WHEN oestrin is injected into ovariectomized rabbits, a maximal hyperemia develops in the uterine tissues within thirty to sixty or more minutes.[1,2] As a result of this, changes in the distribution of fluid in the uterus take place within the next six hours,[3,4] as metabolic processes in the uterus are stimulated.[5,6] After ten or more hours, intermittent contractions commence in the myometrium.[5,6,7]

The little-known fact that the initial hyperemia can be temporarily inhibited in unanesthetized rabbits by the injection of atropine[2] suggests that the primary agent which initiates this series of changes, particularly the vasodilatation, may be acetylcholine which increases in amount under the influence of oestrin. In order to test this hypothesis, assays of the acetylcholine content of the uteri of ovariectomized rabbits, some of which were untreated and others of which received oestrone, were made. The latter group includes one rabbit in which the uterus, minus the cervix containing the uterine cervical ganglia, was transplanted to the anterior abdominal wall. The rabbits were ovariectomized for seventeen to twenty-eight days, except one which had been operated only two weeks, and one that was castrated longer than two months. Extraction of the uterus was carried out by the method recommended by Chang and Gaddum.[8] The extracts so obtained were assayed as recommended by these authors, using the rectus abdominis muscle of the frog. The confirmatory tests include potentiation of the action of the extracts by eserinizing the frog muscle; inhibition of responses by atropine; inactivation of the extracts by sodium hydroxide and inactivation by blood. The quantity of extract obtained was too small to permit testing of the stability of the active material by boiling.

Of twenty-eight ovariectomized rabbits used thus far, fifteen were untreated and yielded extracts giving the following results: six tests on the uneserinized frog rectus were negative, two showed an activity equivalent in one case to 0.2 gamma of acetylcholine per gram of uterus, the other, unaccountably, showed an activity of 5 gamma per gram of uterus. This could not be confirmed with a larger amount of extract on the eserinized preparation. All fifteen extracts were tested on the eserinized rectus preparation. Ten of these showed no activity, and five showed an activity equivalent to 0.06 to 0.13 gamma of acetylcholine per gram of uterus. In no case was sufficient extract available for any of the confirmatory tests.

Thirteen uteri extracted one hour after the injection of one hundred international units of oestrone (Amniotin, Squibb) per kilogram of body weight gave the following results: eight tests on the uneserinized rectus were made, six of which were positive, showing an activity equivalent to 0.5 to 2.0 gamma (in one case, 4 gamma) per gram of fresh uterus, and two of which were inactive. Twelve of the thirteen extracts were tested on eserinized rectus preparations. Two were inactive and one showed only a trace of activity. In the nine remaining cases positive responses were obtained. Seven of these which had been tested previously on the uneserinized muscle showed potentiation of the responses. Atropine inhibition was attempted with five extracts (including the one from the transplanted tissue), and in each case inhibition was observed. Three attempts to inactivate the active agent in extracts with sodium hydroxide were successful, including inactivation of a sample from the transplant. Two attempts to inactivate this substance by mixing it with blood for about one minute were made. One, with human blood was successful, the other, with rabbit blood showed a diminution of about two thirds in the magnitude of the response.

Recent experiments indicate that twelve hours after injection of oestrin no acetylcholine-like substance can be extracted from the uterus.

These results show unmistakably that the acetylcholine content of the uterus is significantly increased within one hour after the injection of oestrin. Since the effect occurred in a transplanted uterus, connection with the central nervous system is not essential, although in this experiment, time for complete degeneration of the nerves had not elapsed.

In the sense therefore that certain nerve effects upon effector organs are mediated by local liberation of acetylcholine and accordingly are said to be "cholinergic," it is clear that oestrin, under the conditions of this work, is similarly "cholinergic." Hence this term must be broadened to include possible hormonic effects which are mediated peripherally by acetylcholine. In this way, the maximal hyperemia which occurs in uterine transplants in which no nerves have been demonstrated[1] may be explained, and so, perhaps, may the high oestrin content and the high acetylcholine content of human placenta[8] be explained, in the complete absence of nerves in this tissue.[9]

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INFLUENCE OF BILE ACIDS ON EROSIONS OF THE CHICK GIZZARD LINING

EXPERIMENTAL results indicating the necessity of an organic dietary factor for the maintenance of a normal gizzard lining in the chick, and the prevention of erosions or lesions of the lining have been given in a number of papers.[1, 2, 3, 4] A series of experiments on the rôle of the bile acids in this deficiency disease may now be reported.

The feeding of whole bile by oral administration or by mixing with diet or as commercial dried bile tablets has been found to prevent the development of the roughened and eroded gizzard lining characteristically found in chicks fed the basal diet without supplement. In other experiments, vacuum concentrated whole beef bile, cholic acid, deoxycholic acid, sodium glycocholate and sodium taurocholate were used as supplements to the basal diet. All these showed a marked protective action against the development of gizzard lesions. In all these experiments vitamin K in the form of an extract of alfalfa was added in a constant amount just sufficient to maintain an approximately normal blood-clotting time. In one case this vitamin K supplement was added at a level about twenty times that required. Typical results may be illustrated by the data given in Table I.

TABLE I

Supplement to basal diet	Number of chicks	Average weight at four weeks, grams	Average blood clotting time, minutes	Average gizzard erosion score[1, 2]
None	10	290	4.9	0.90
Cholic acid, pure, 0.5 per cent. of diet	10	281	4.6	0.05
Vitamin K supplement 20 times adequate level..	10	283	2.7	0.96

It is apparent that certain components of bile, when added to the diet, protect against erosion and lesions of the gizzard lining. It seems probable that bile may play a definite rôle in the maintenance of a normal gizzard lining.

The separation of gizzard erosions from the vitamin K deficiency syndrome is given further support in the facts that bile is a very poor source of vitamin K[5] and that large doses of vitamin K can be fed without diminishing the incidence of gizzard erosions.

The identity of the chick gizzard factor with any of the components of bile and the mechanism of the action of these components on the gizzard lining will require further research.

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